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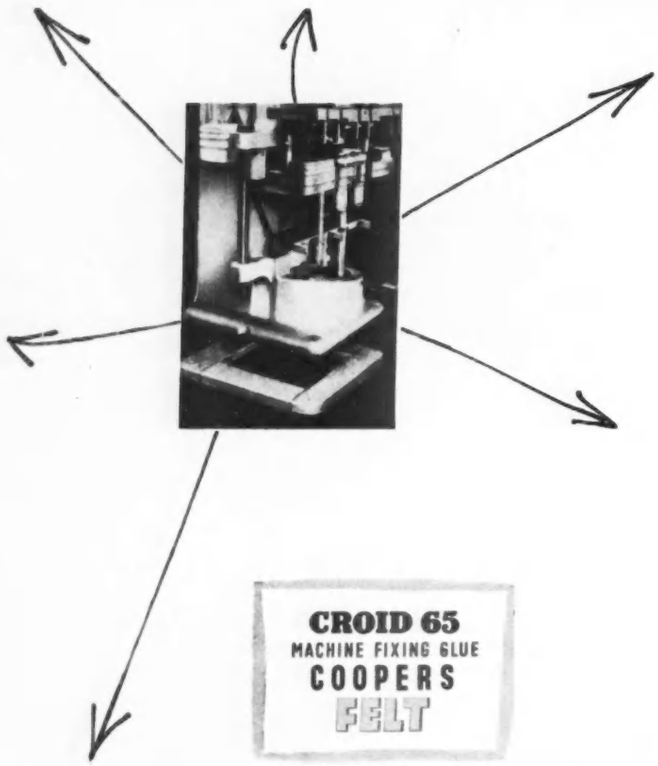

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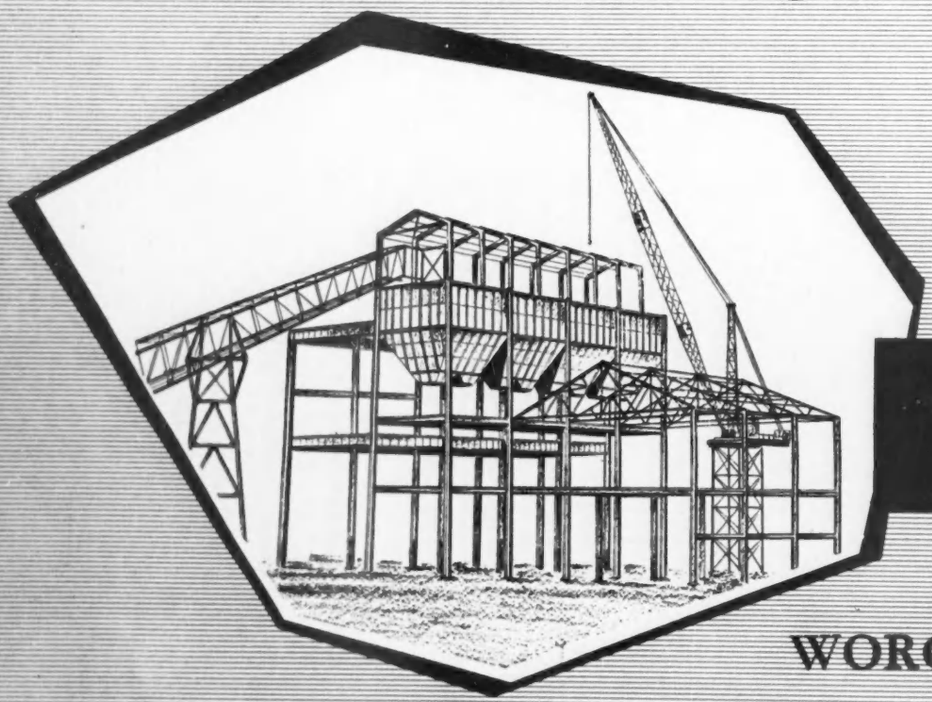

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THE ENGINEER

Established 1856

No. 5336 **MAY 2, 1958** VOL. 205

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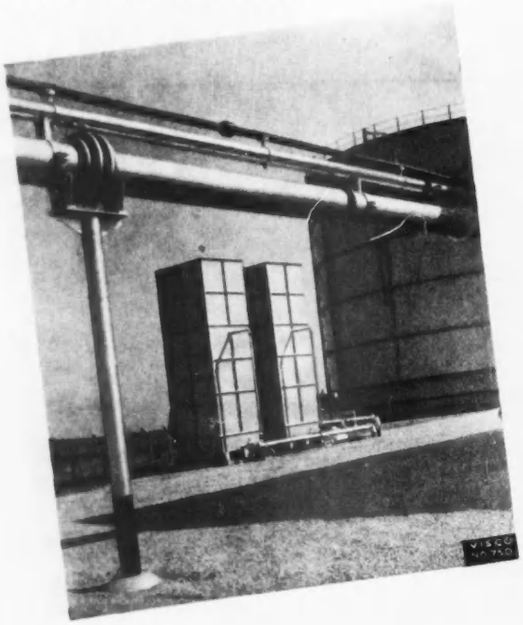

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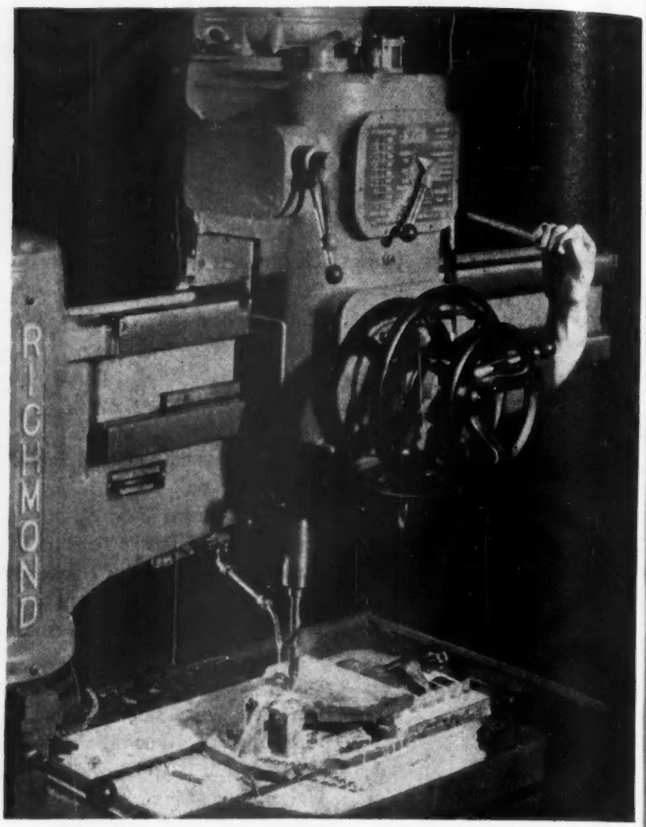

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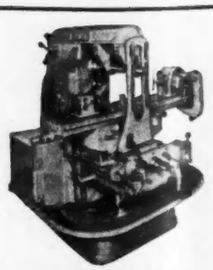

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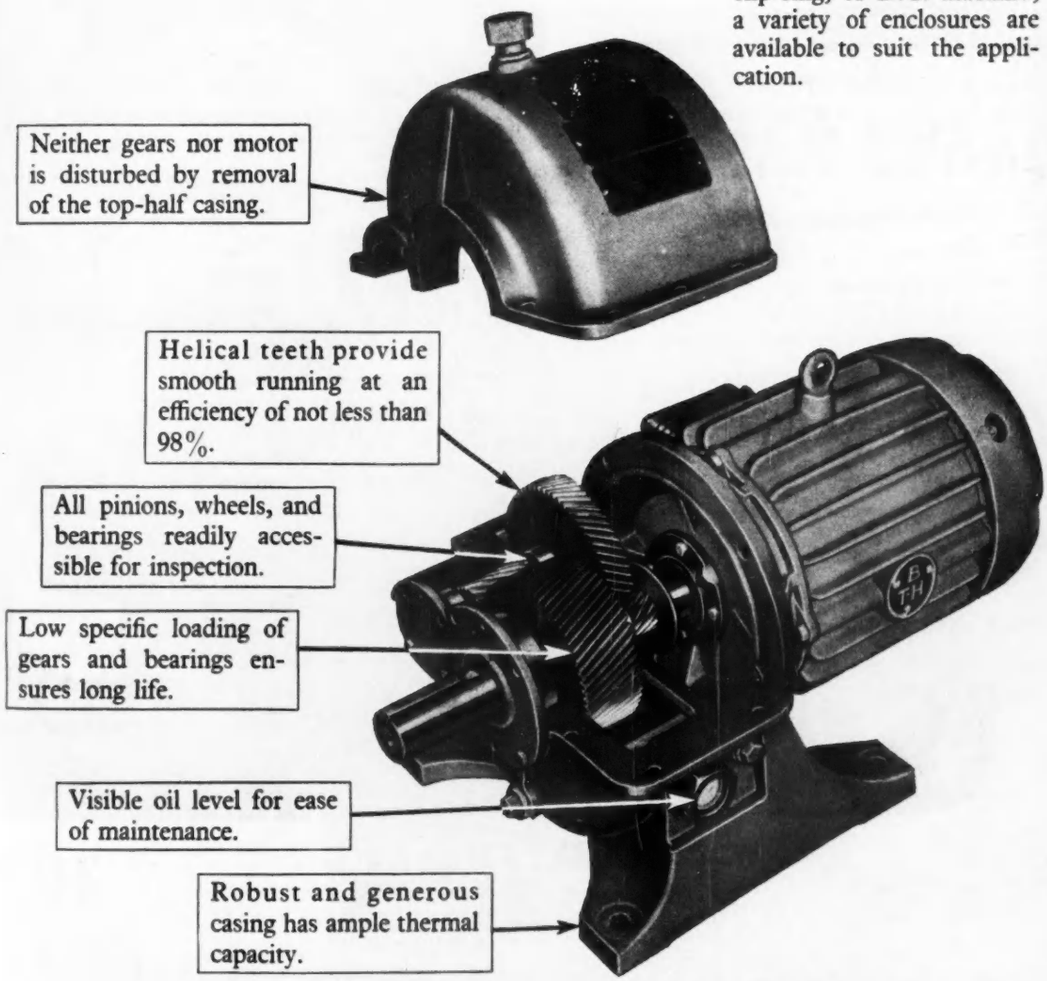
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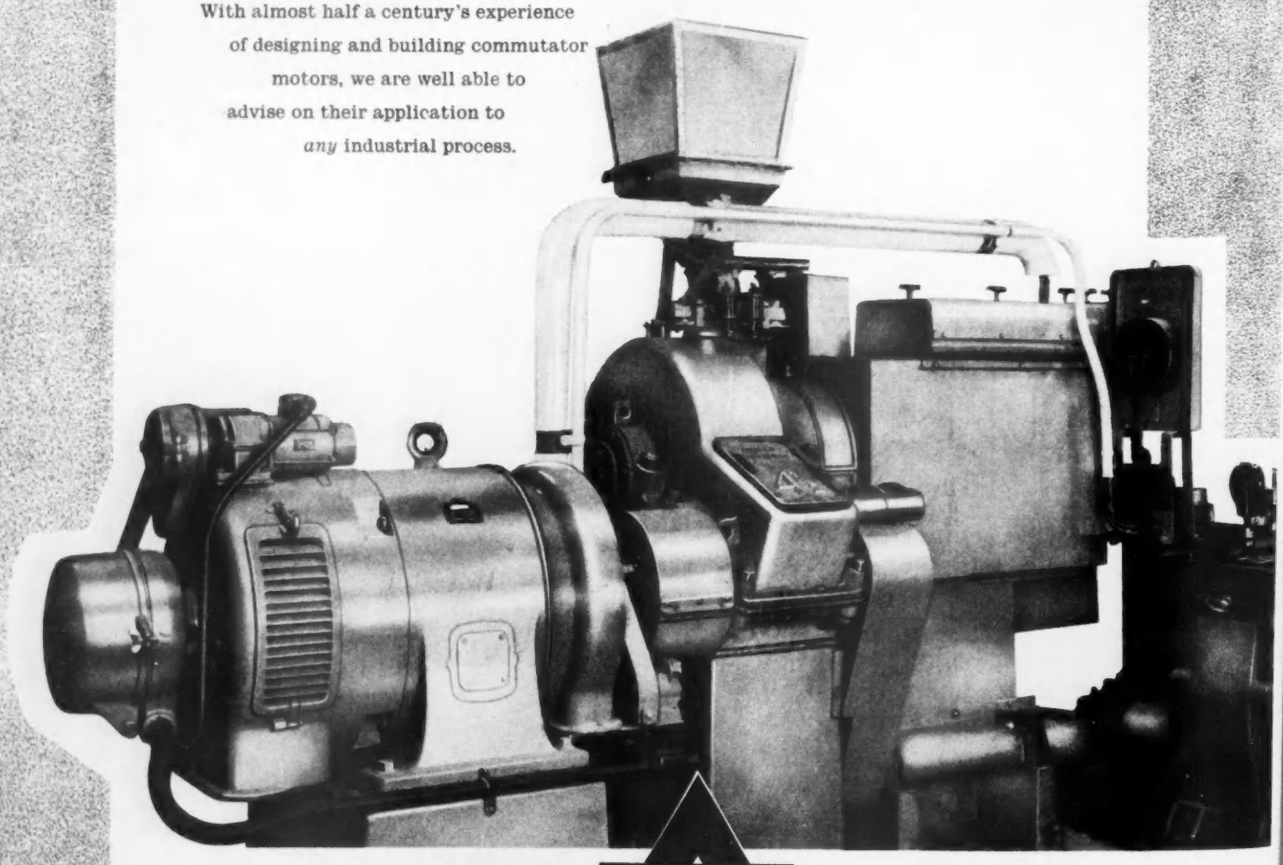

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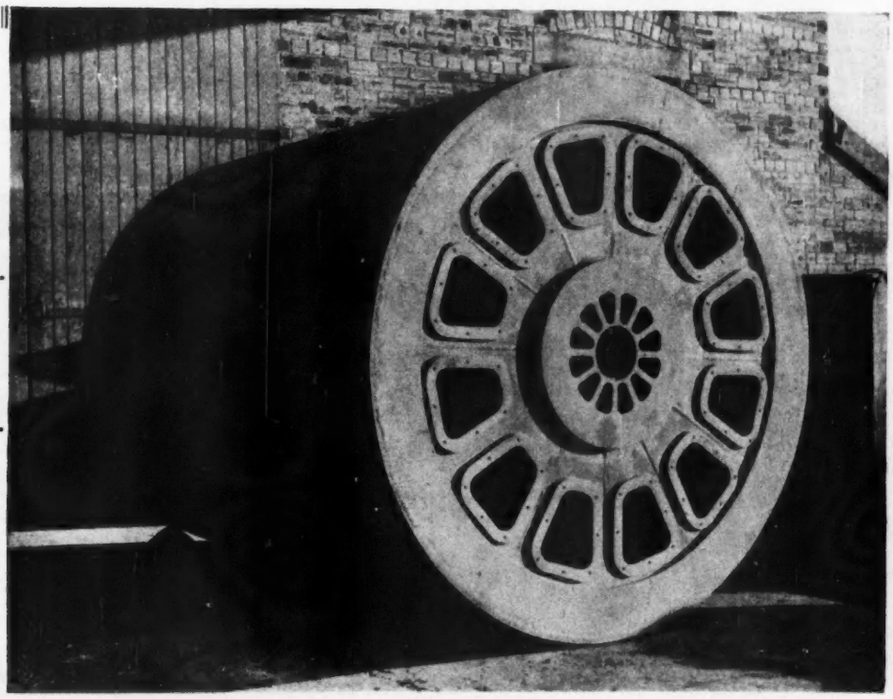

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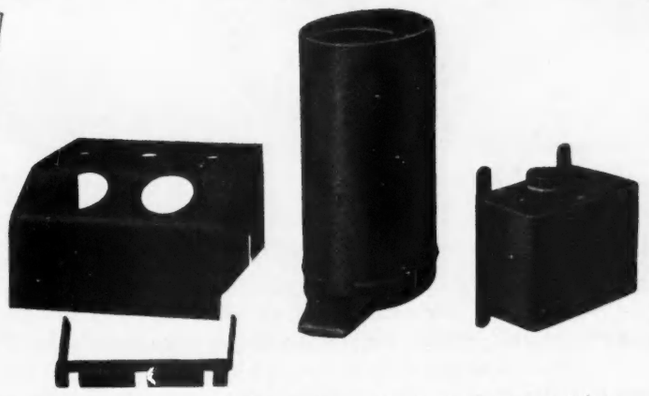

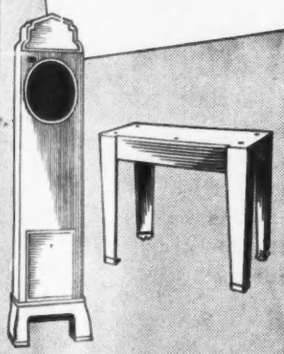

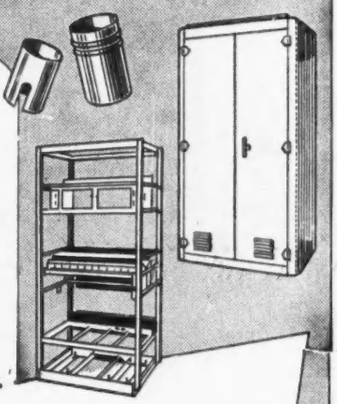

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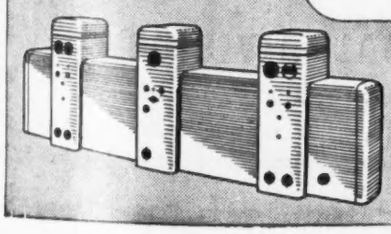

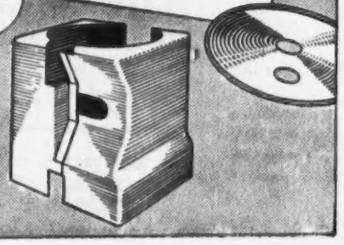

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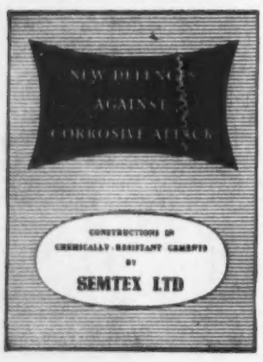

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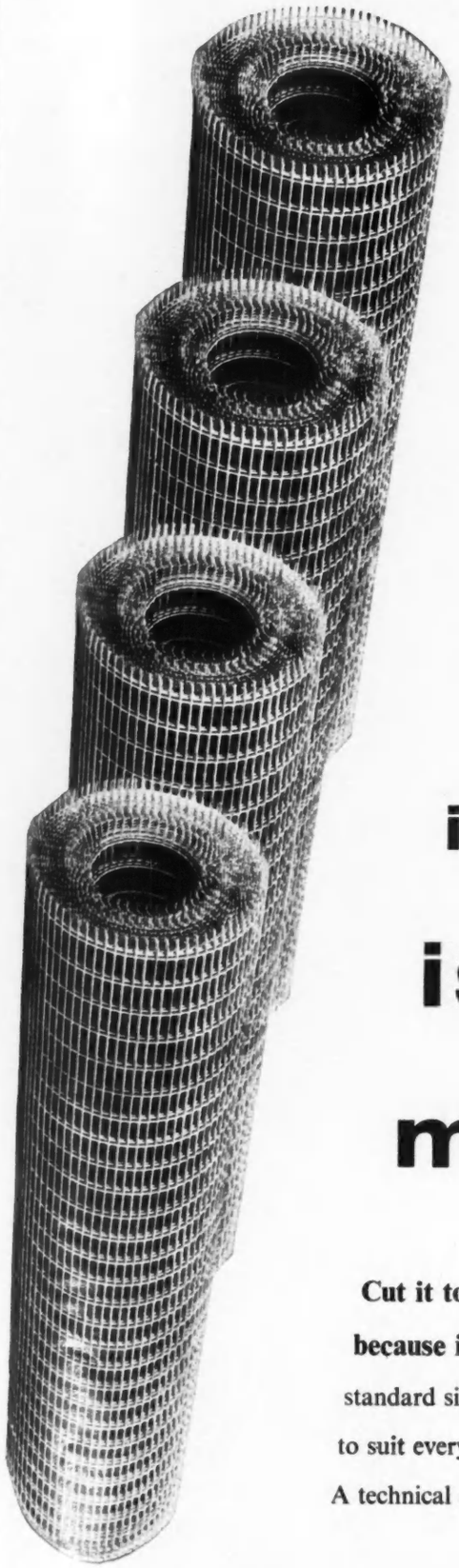

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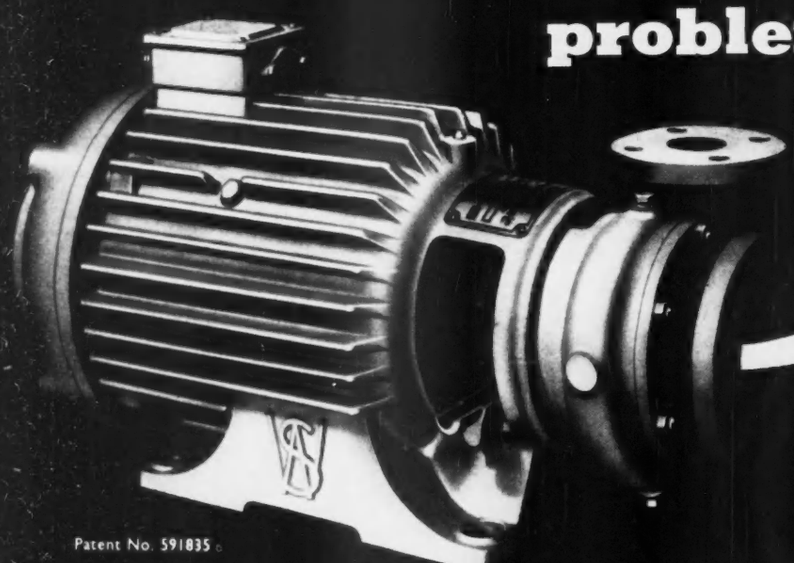

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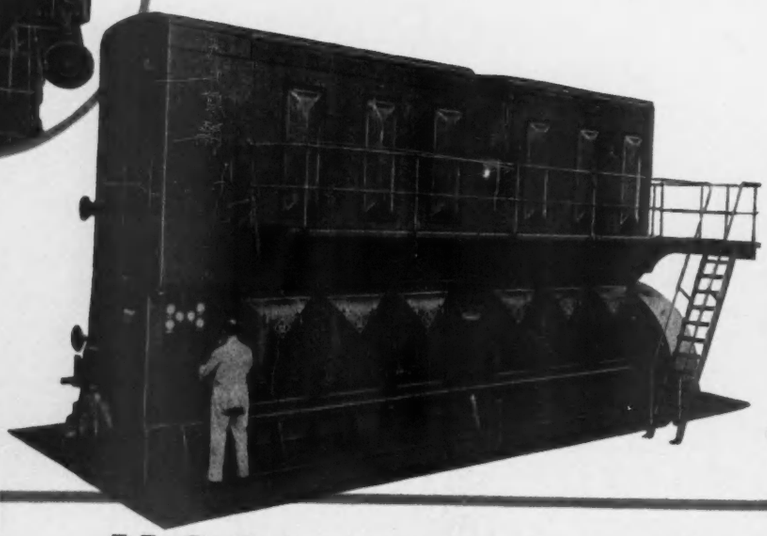

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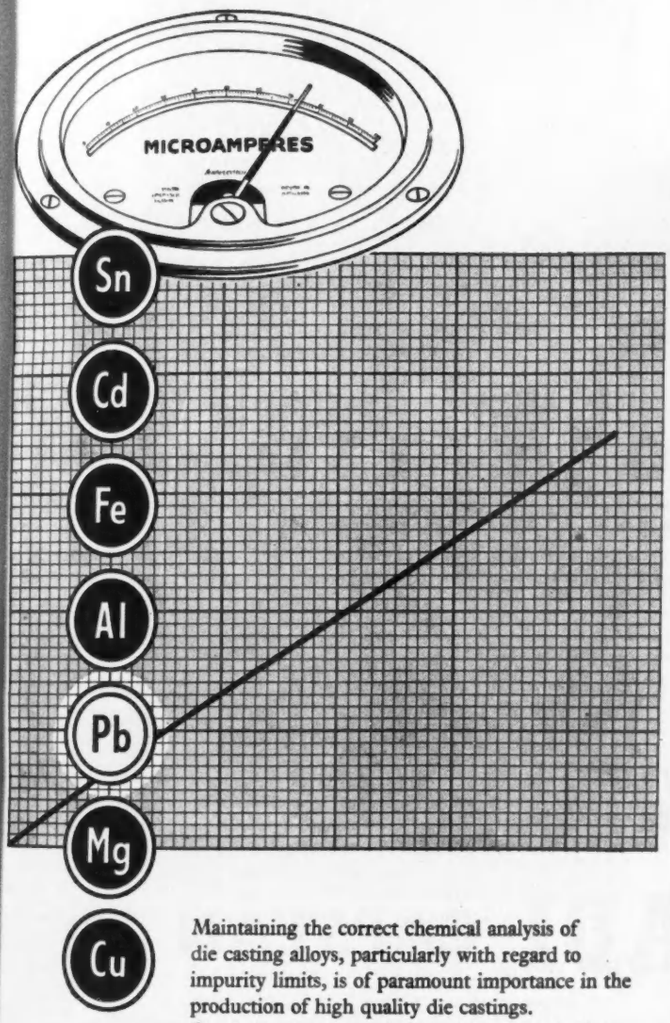

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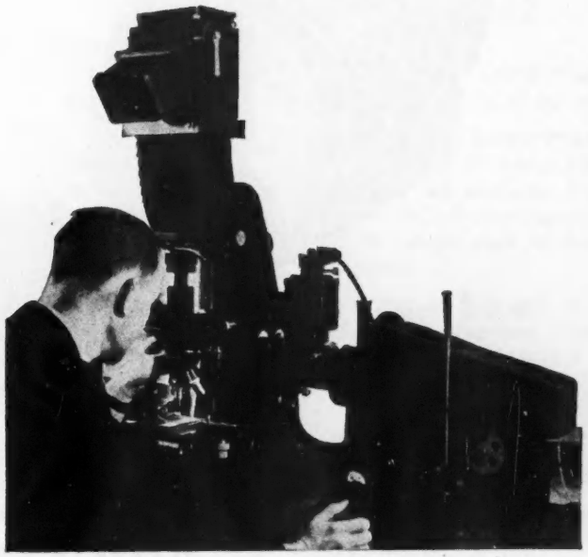

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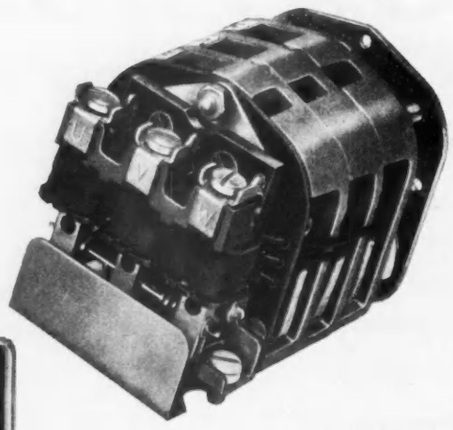

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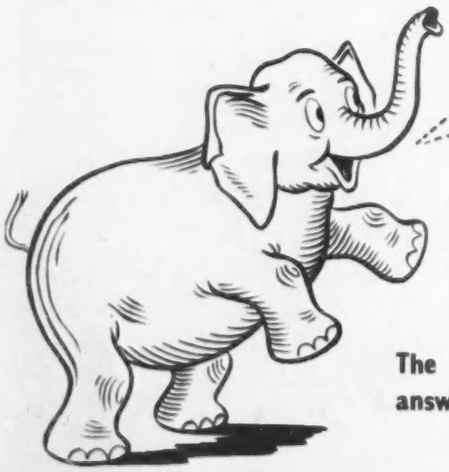

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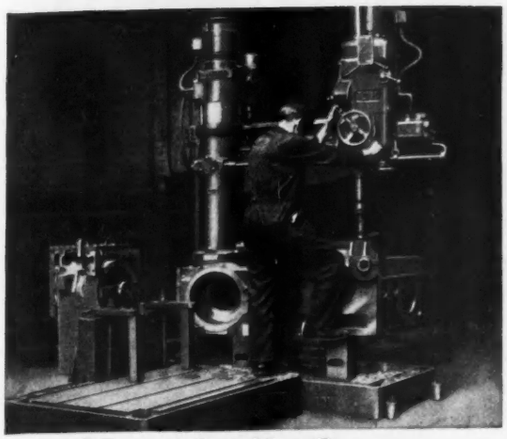

In the production line, this A.E.I. type Radial is drilling and tapping ¾in. B.S.F. and 1in. B.S.P. holes in a Crawler Tractor gear box. Three-way base-plate set-up uses machine to its maximum capacity.

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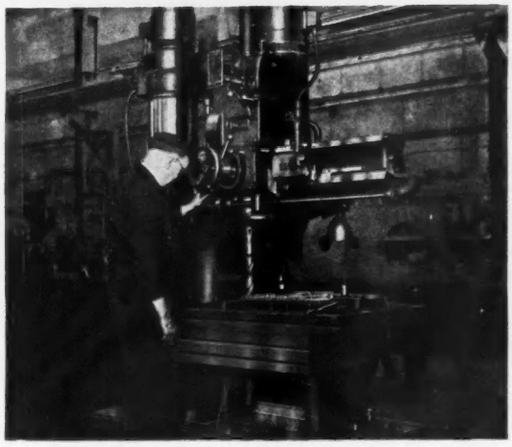

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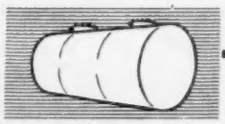

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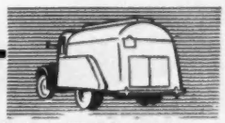

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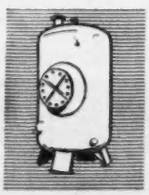

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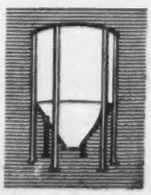

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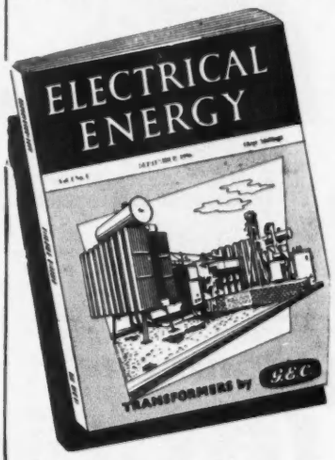

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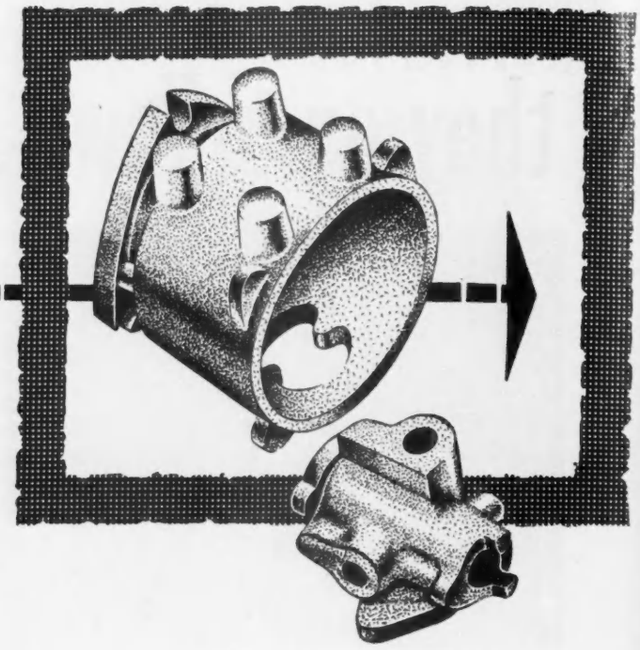

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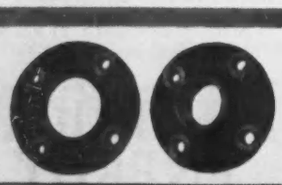

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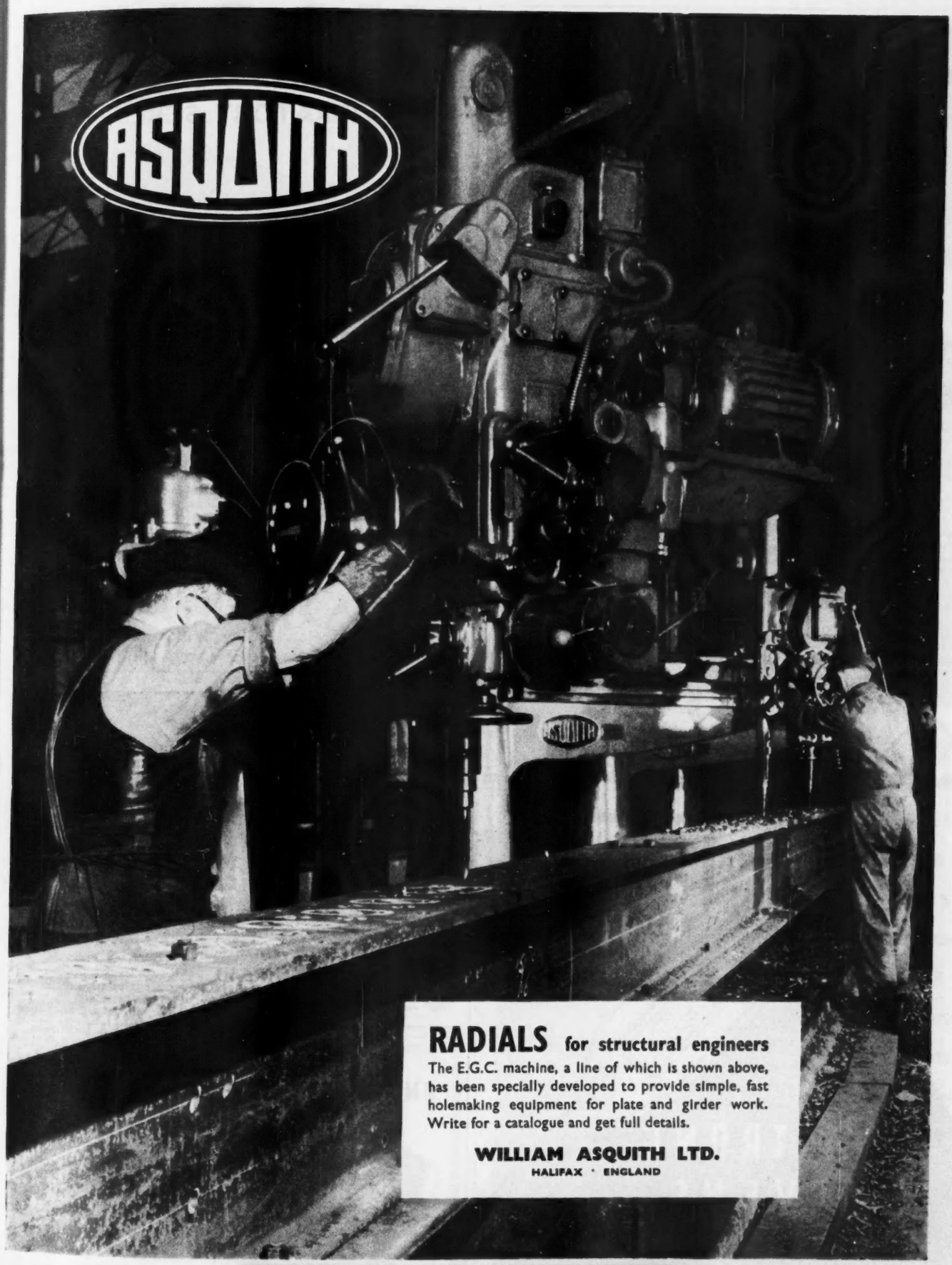

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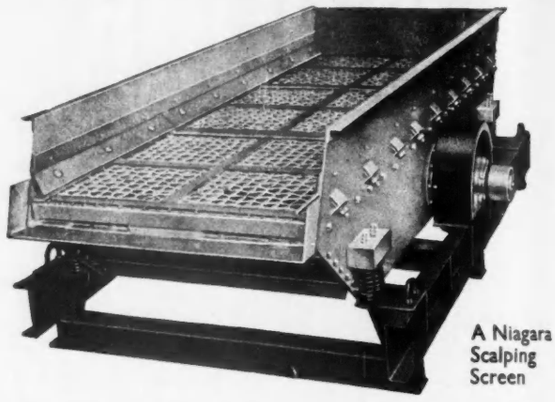

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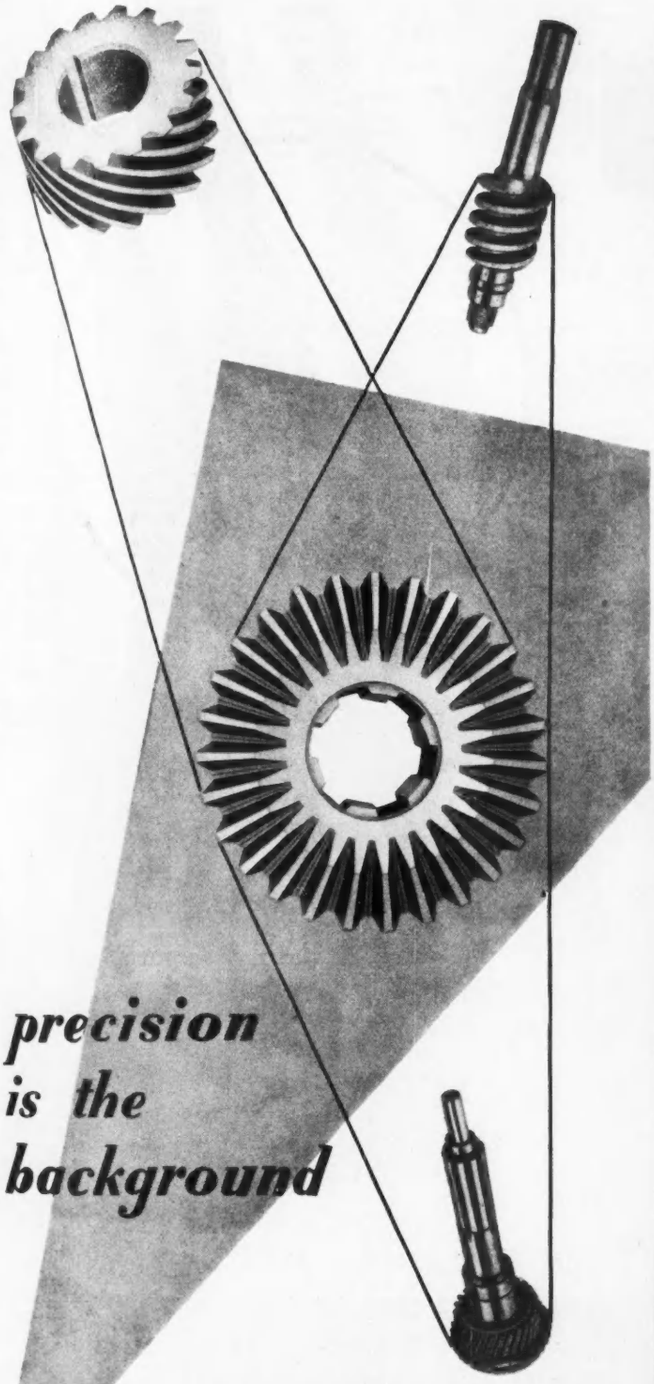

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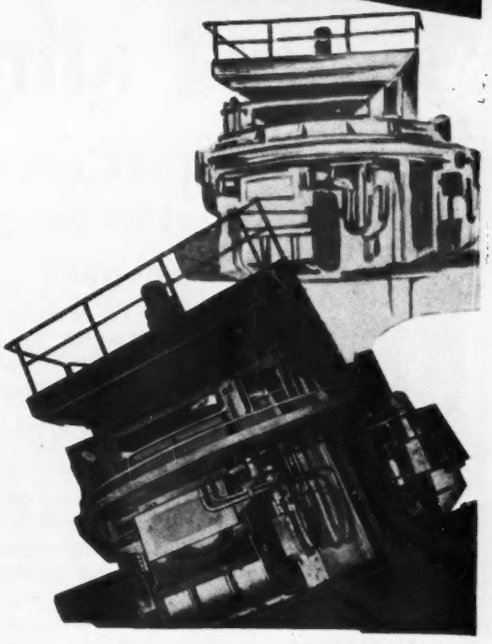

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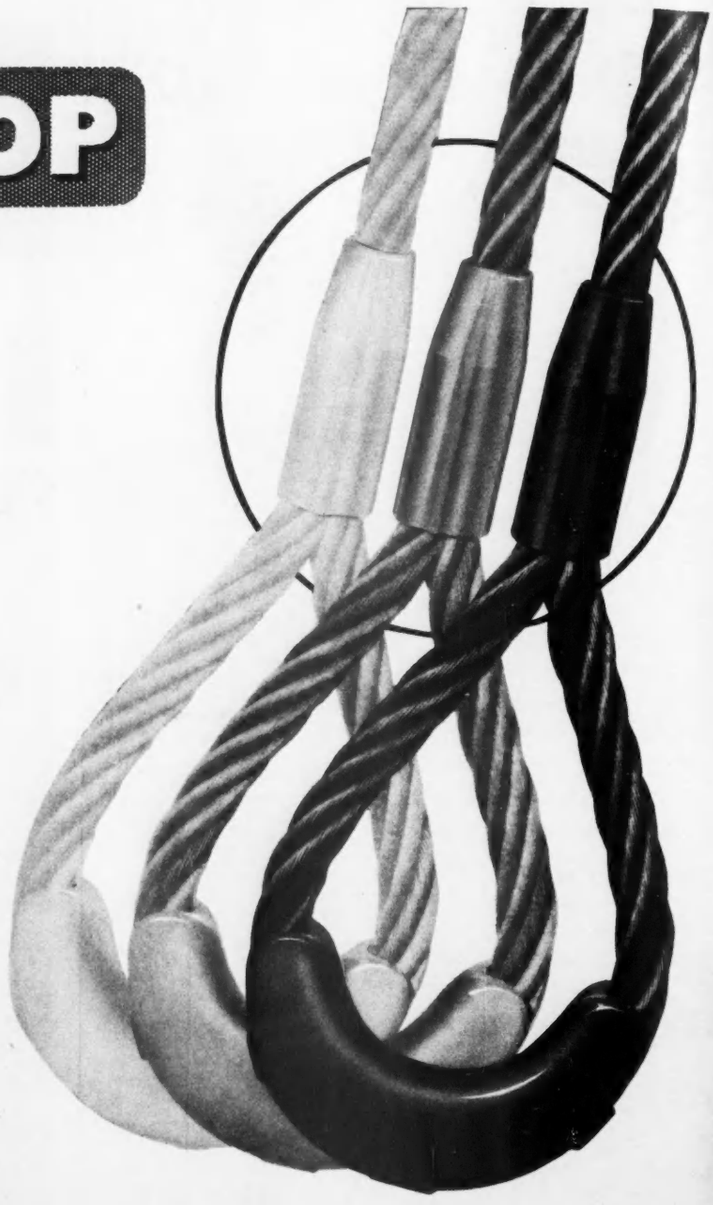

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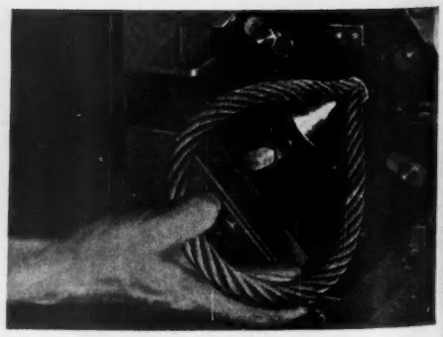

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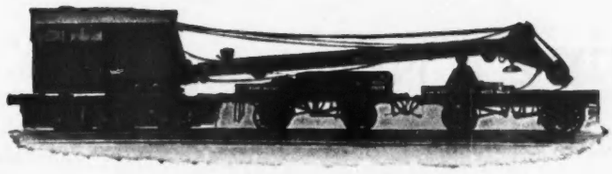

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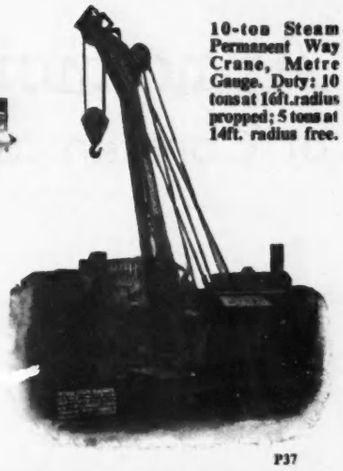

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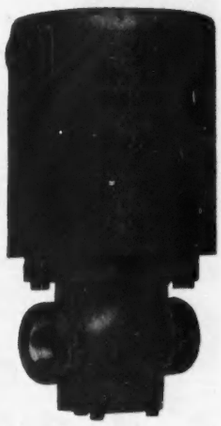

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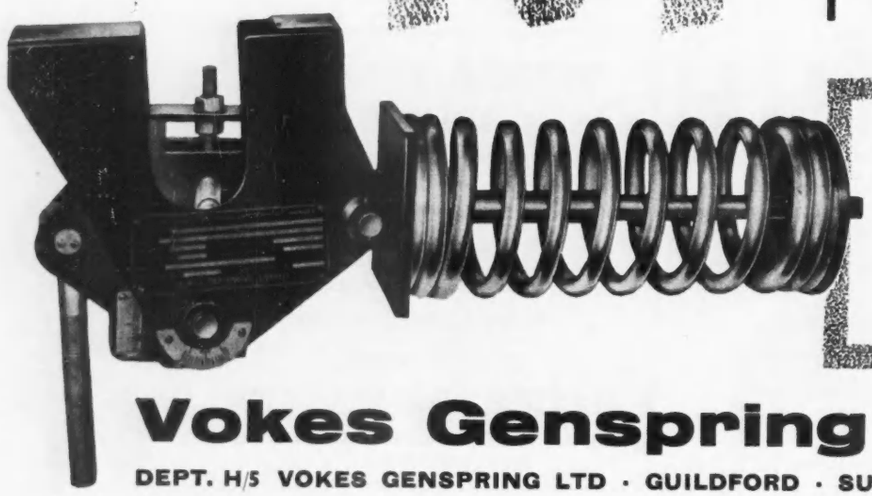

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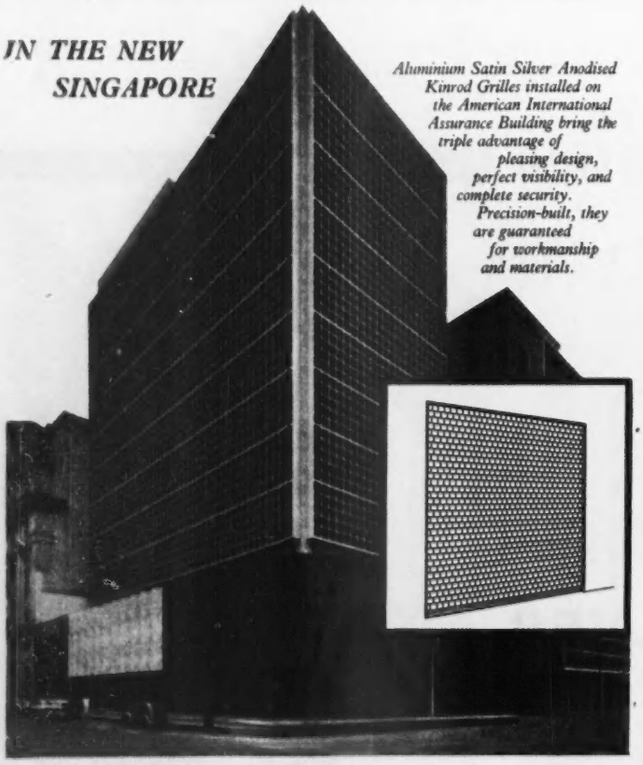

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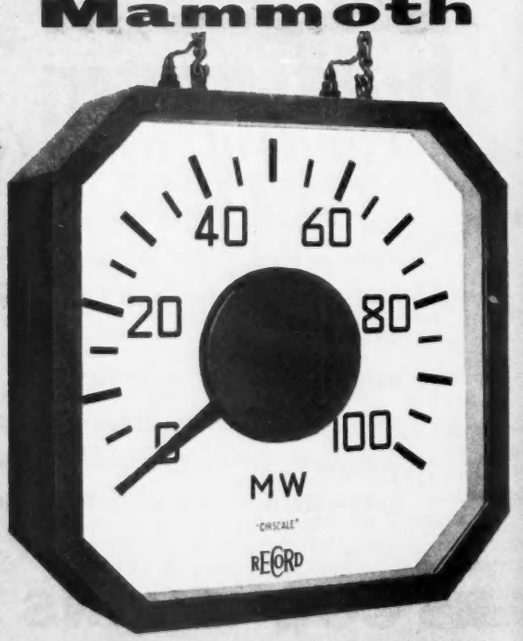

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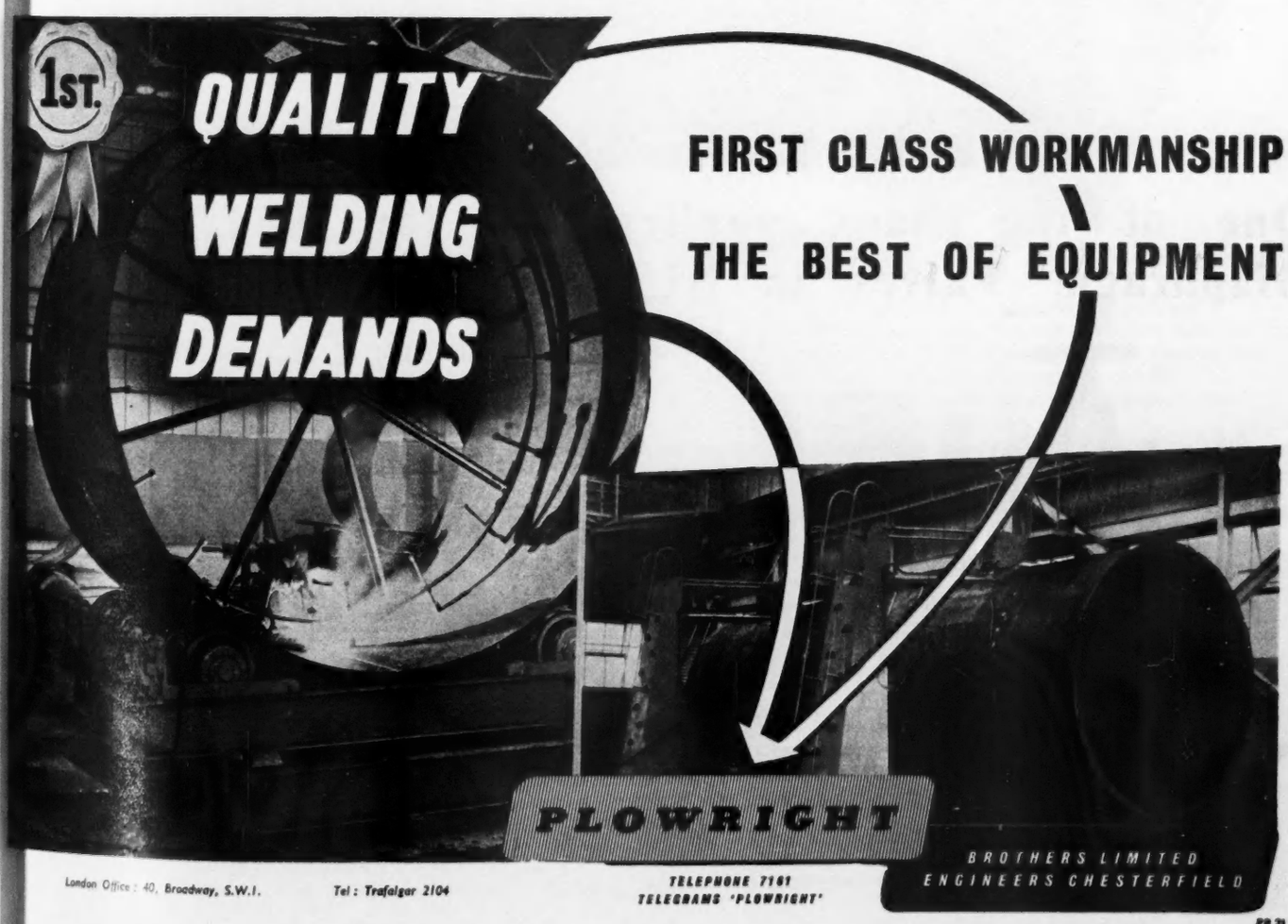

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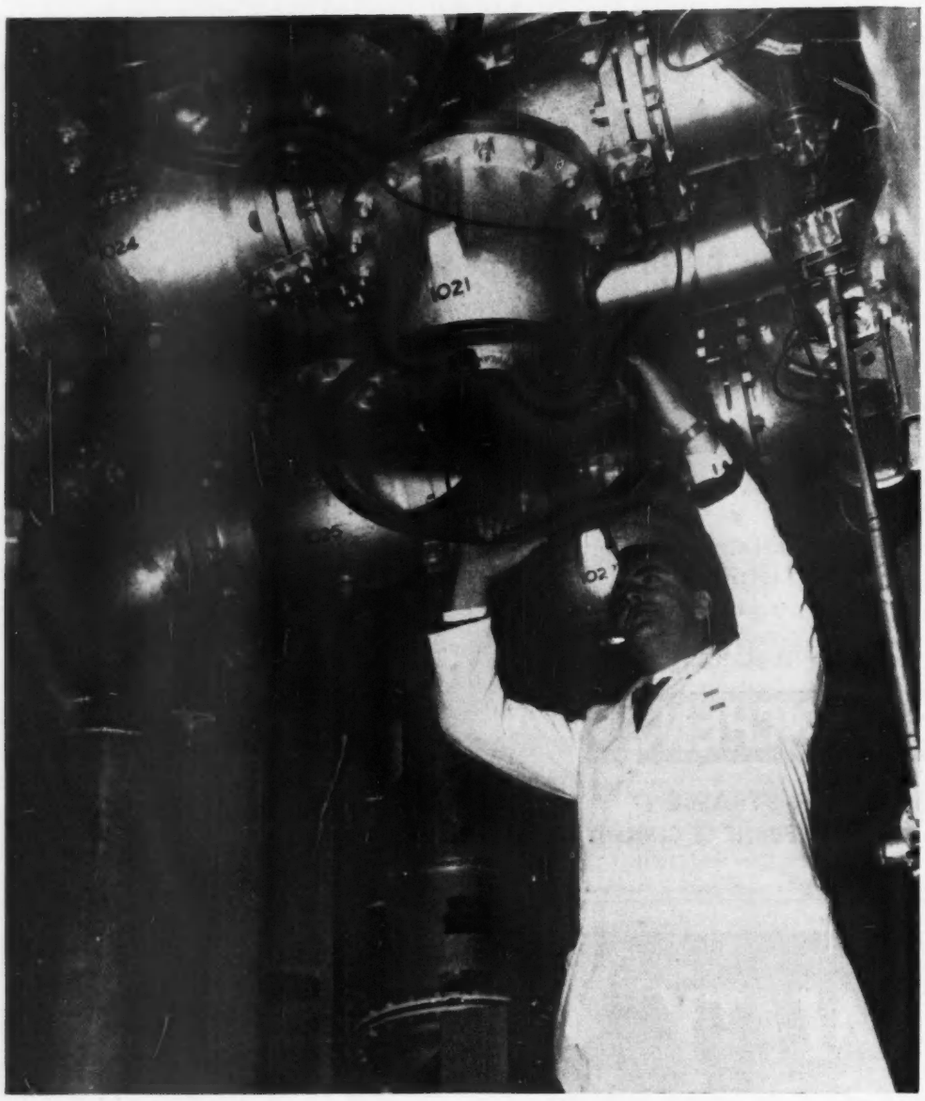

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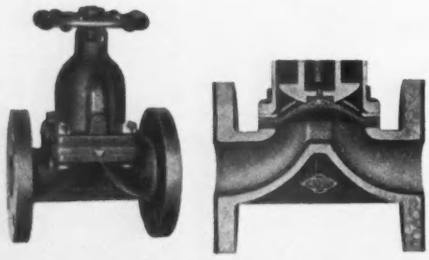

Sealed Bonnet Valve and Lined Body as widely specified for these duties.

In the illustration a technician is seen at the control of a large valve handling heavy water in the Dido reactor at Harwell.

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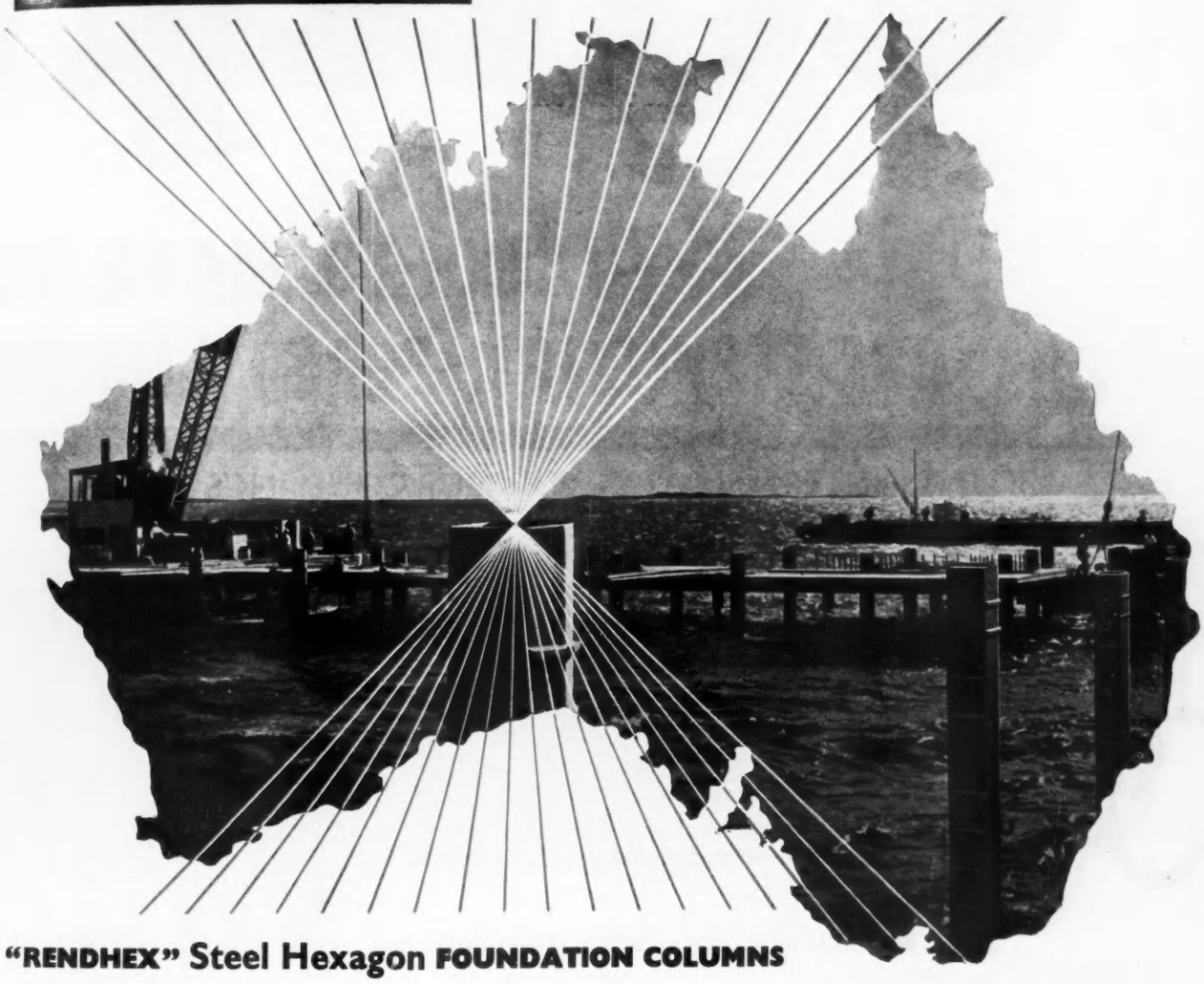

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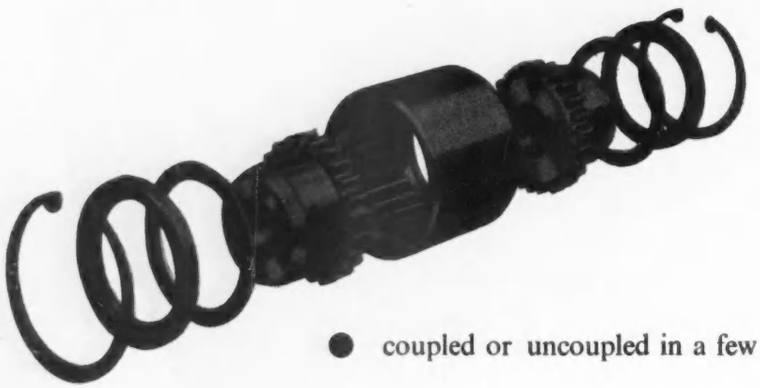

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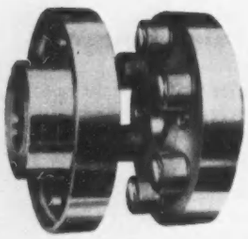

Crown Pin Flexible Couplings
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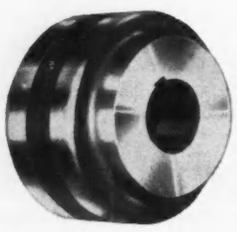

Disc Type Flexible Couplings
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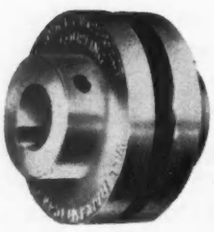

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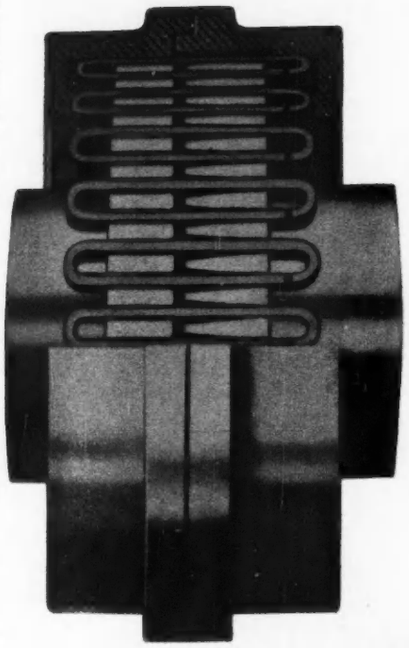

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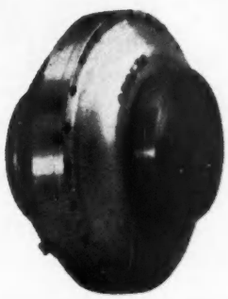

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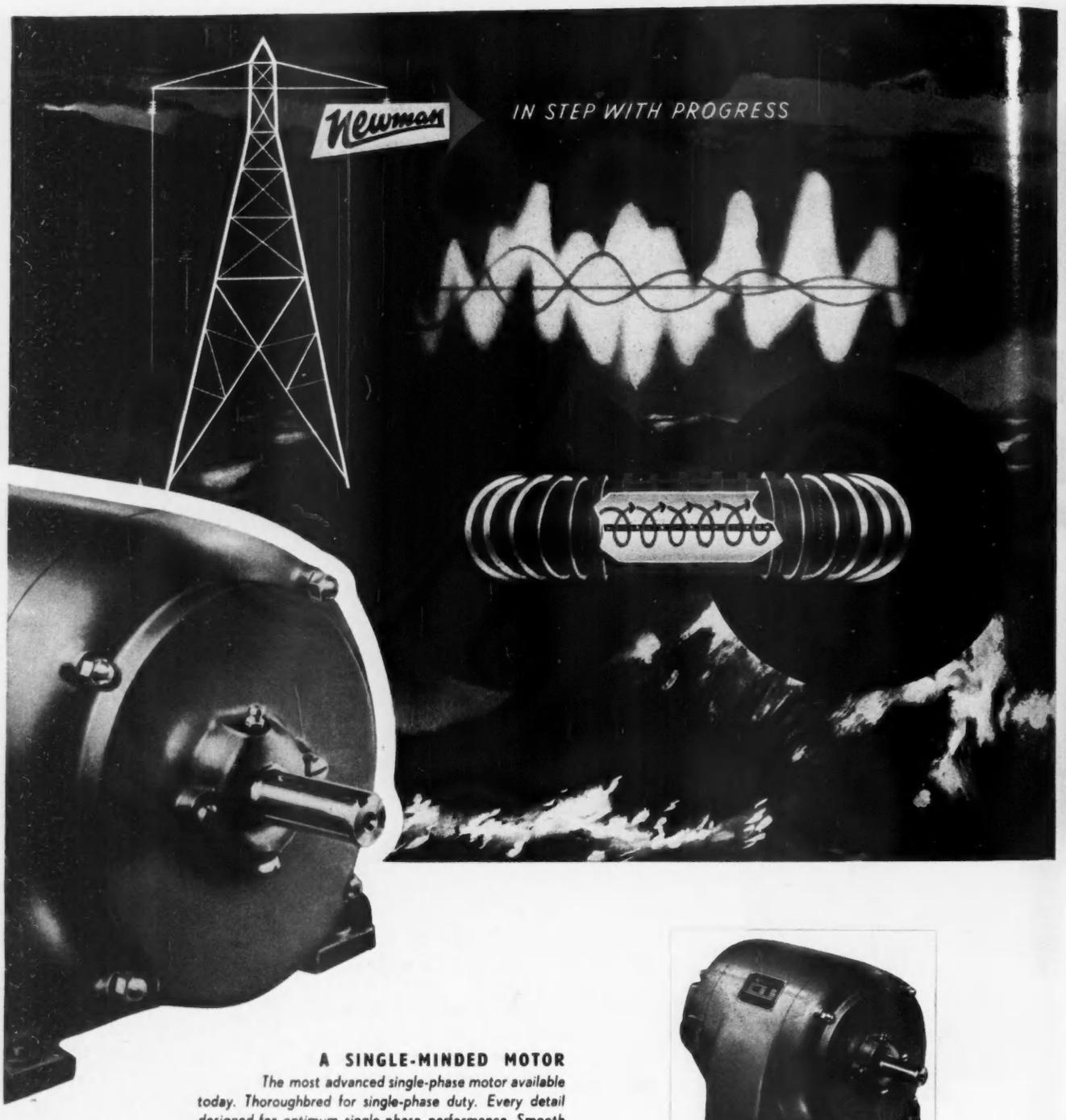

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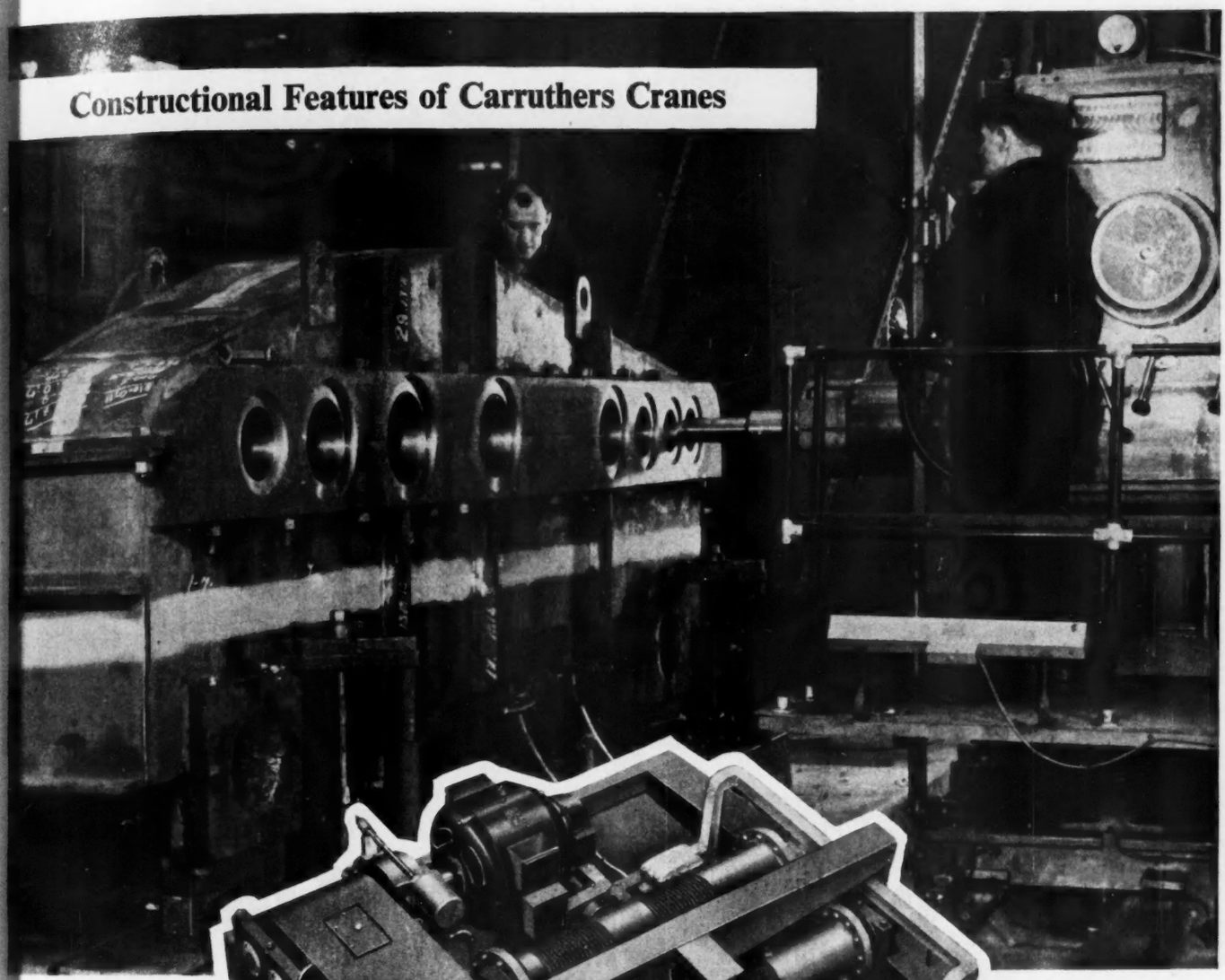

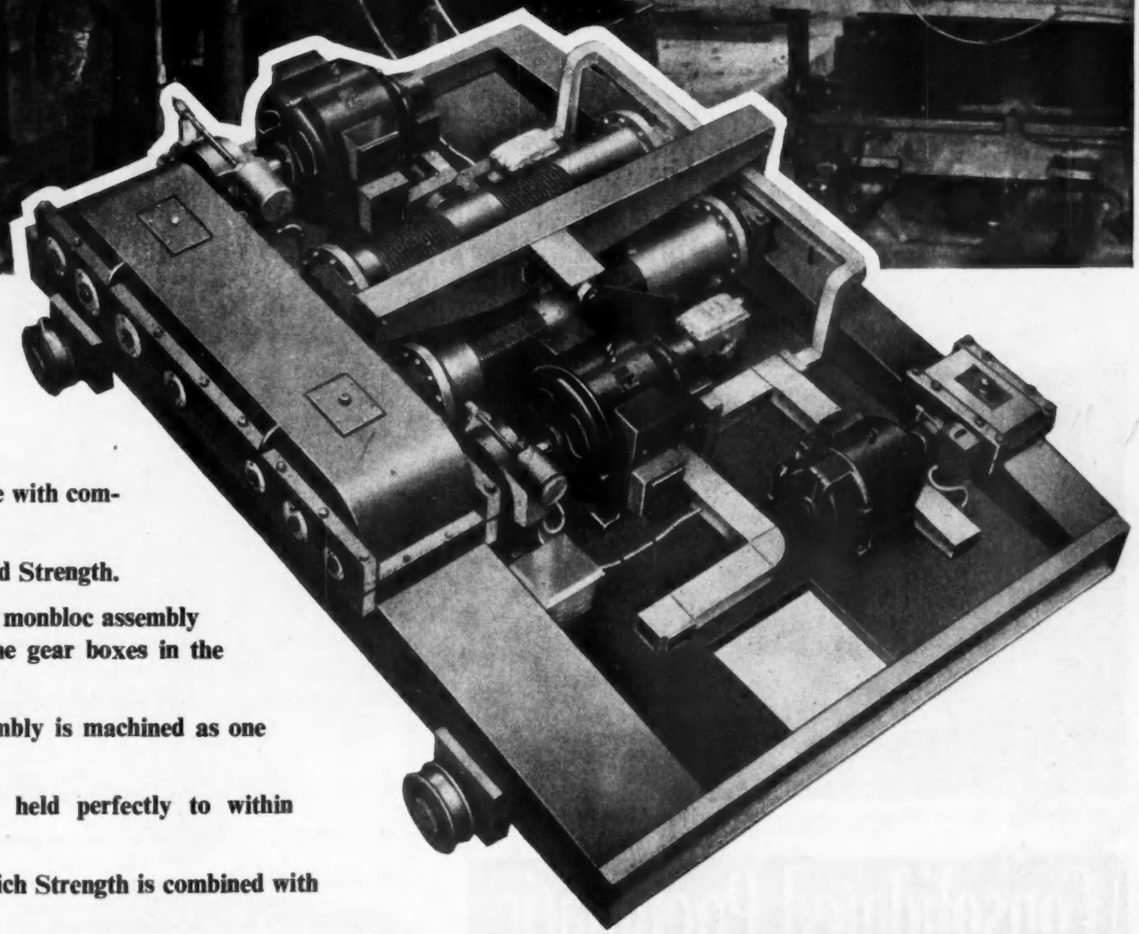

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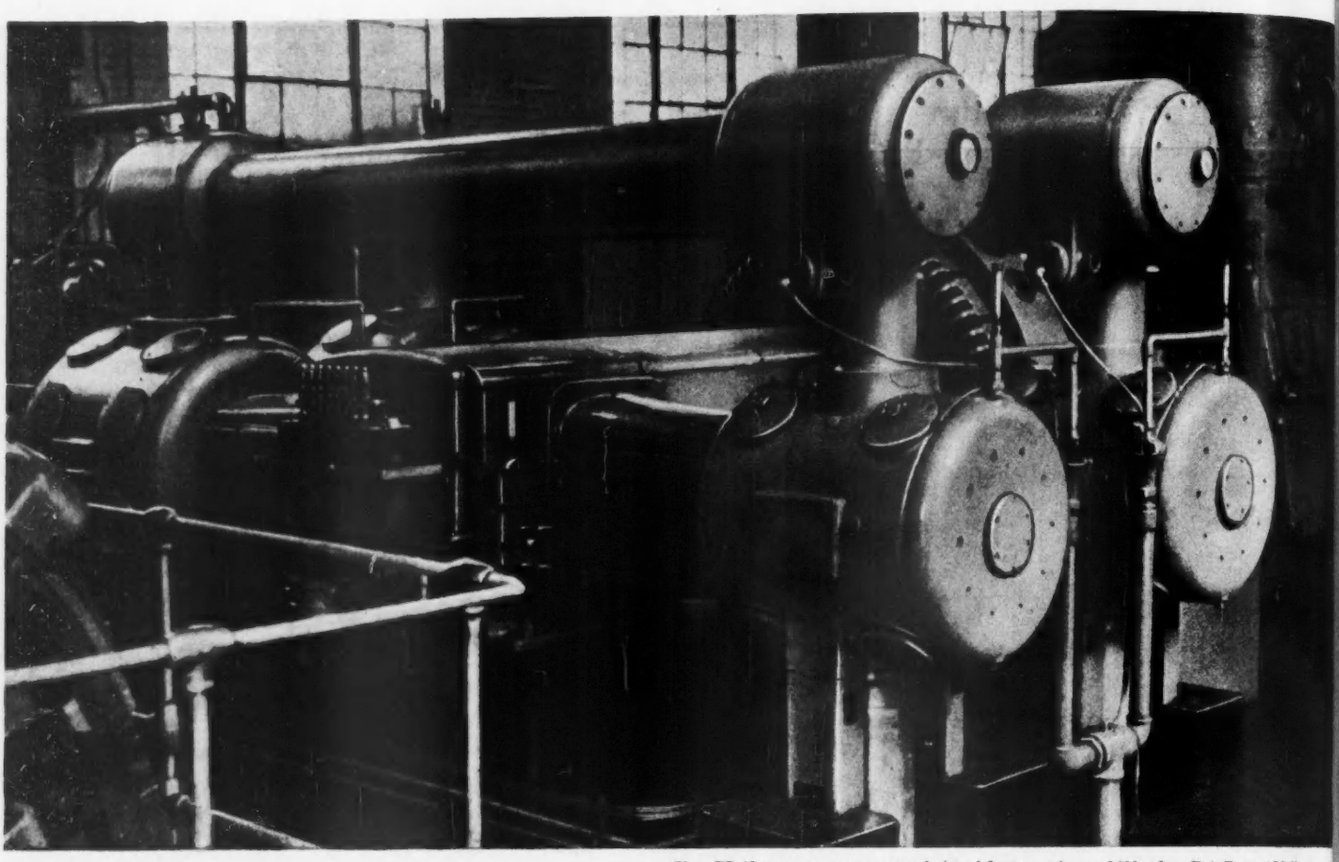

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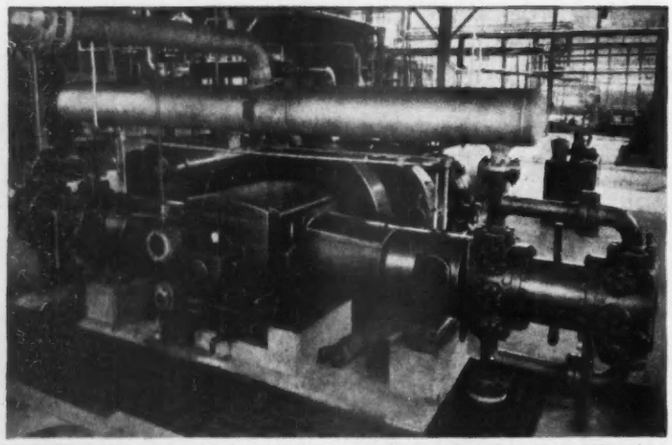

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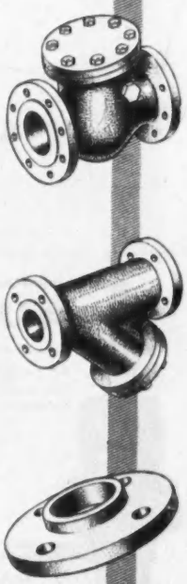

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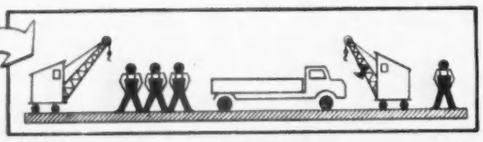

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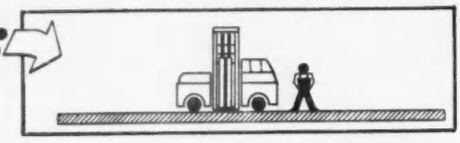

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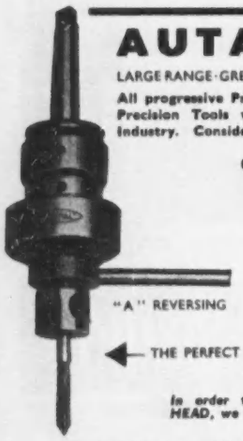

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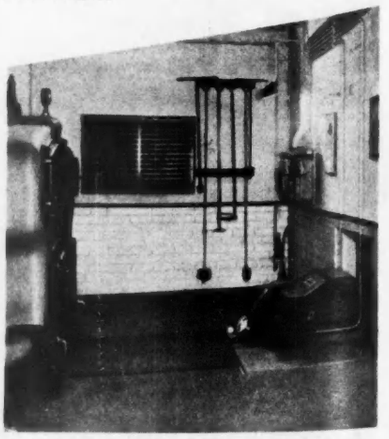

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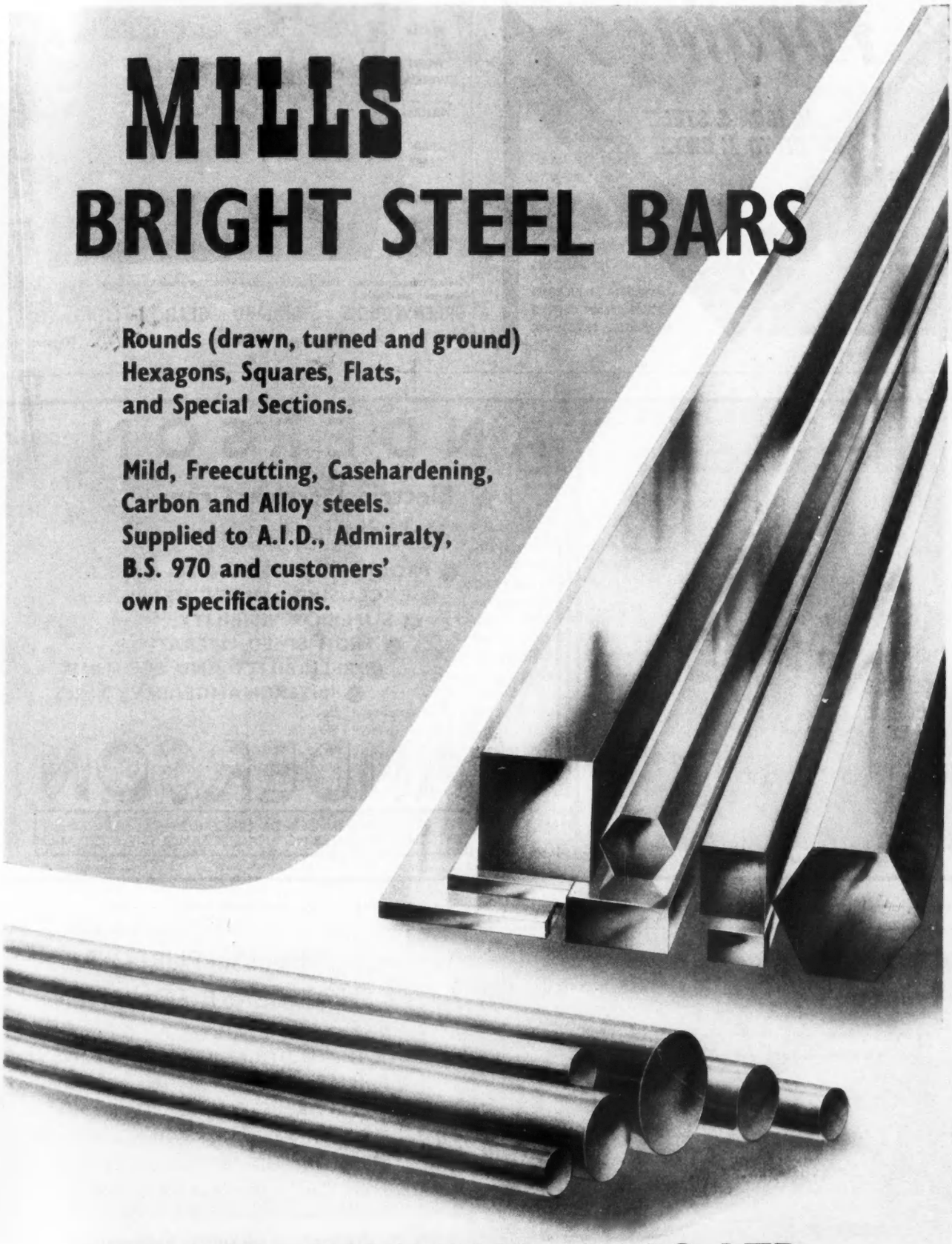

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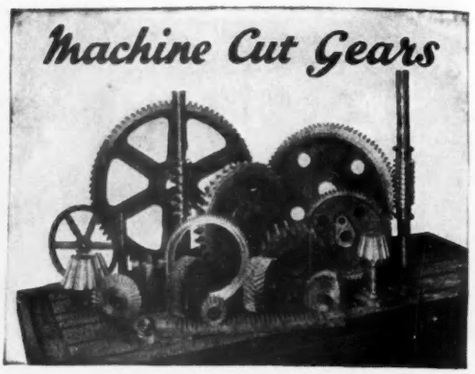

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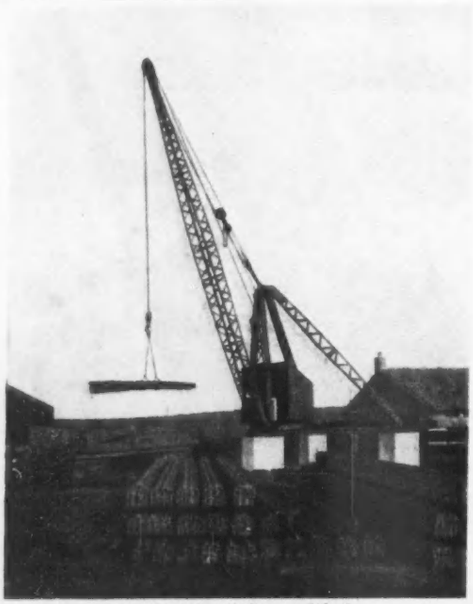

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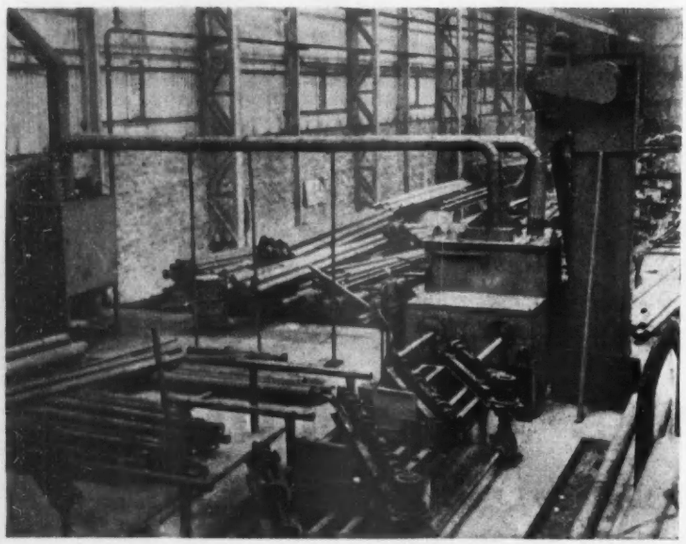

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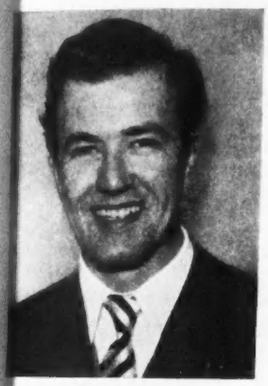

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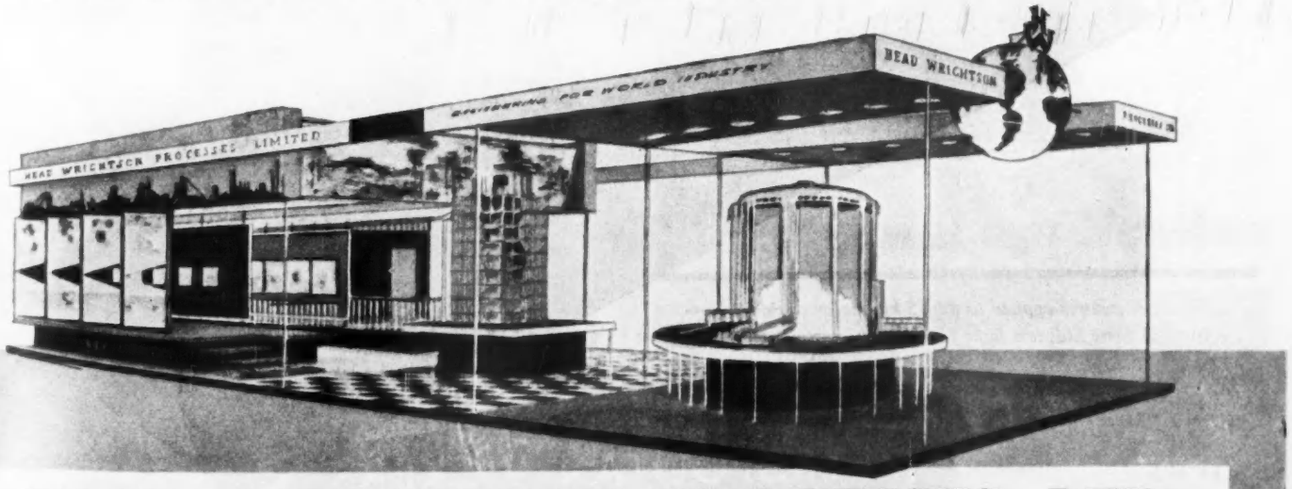

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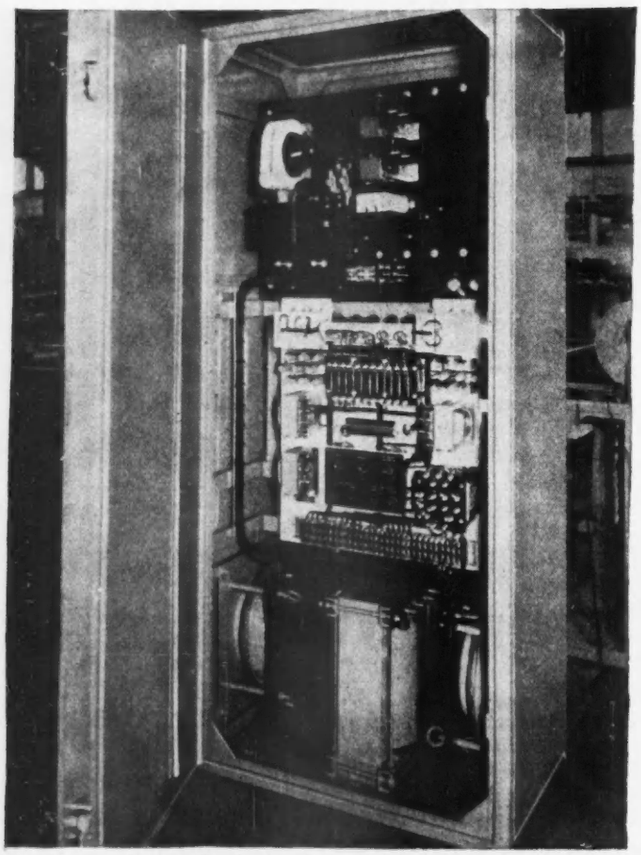

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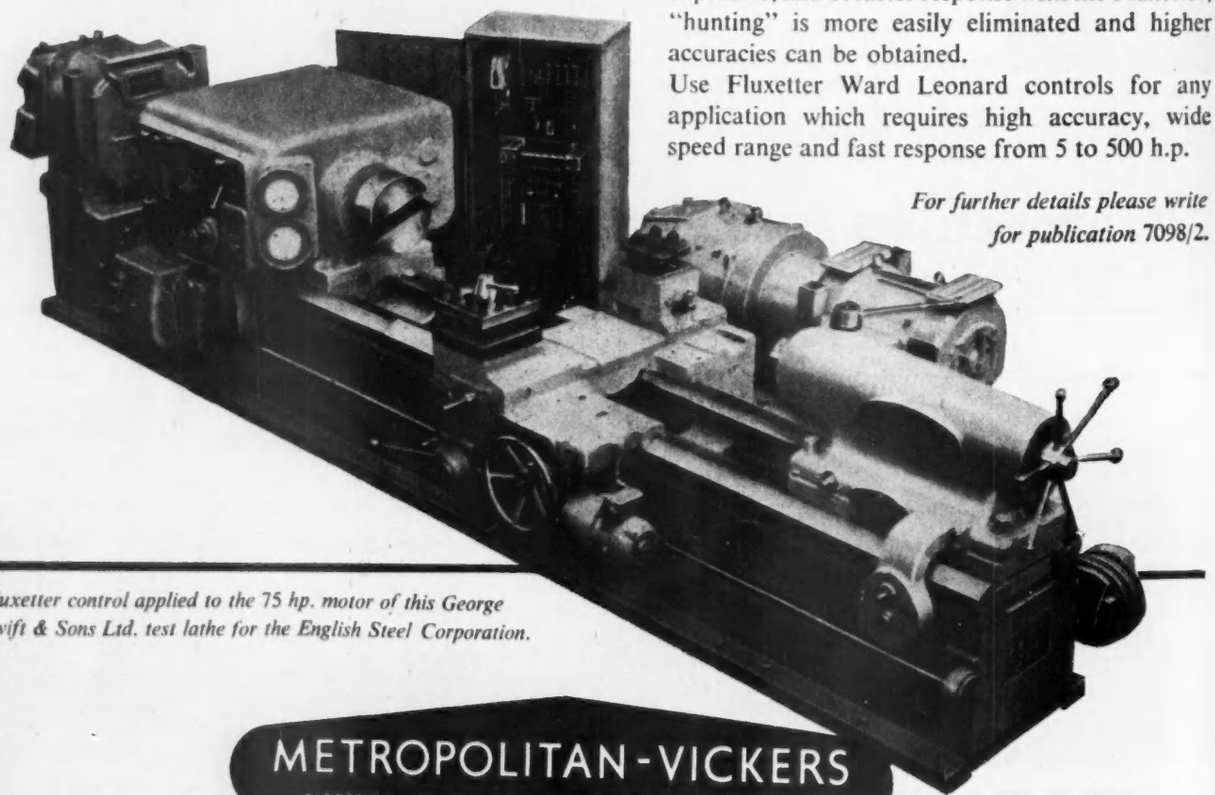

Fluxetter control applied to the 75 hp. motor of this George Swift & Sons Ltd. test lathe for the English Steel Corporation.

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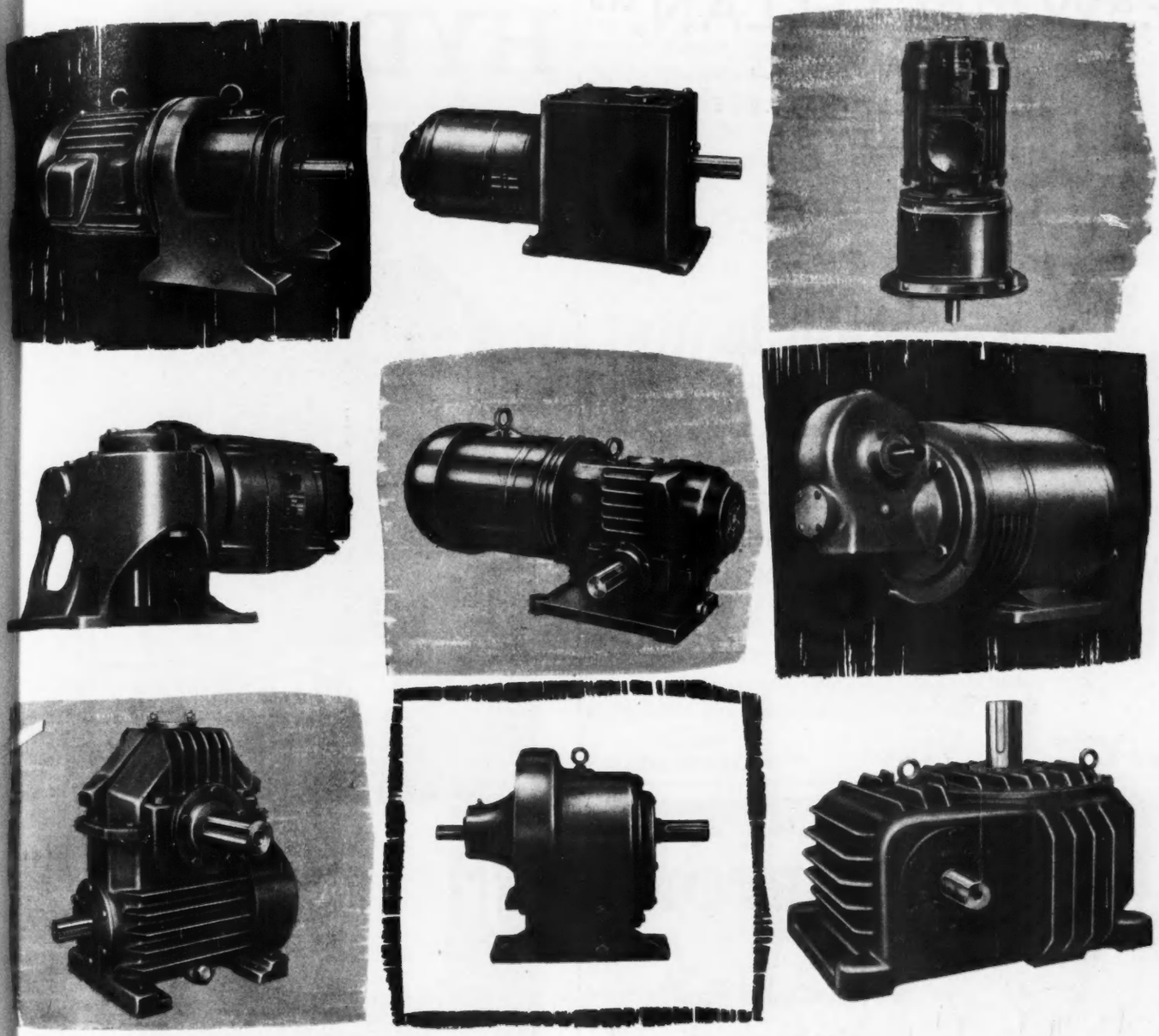

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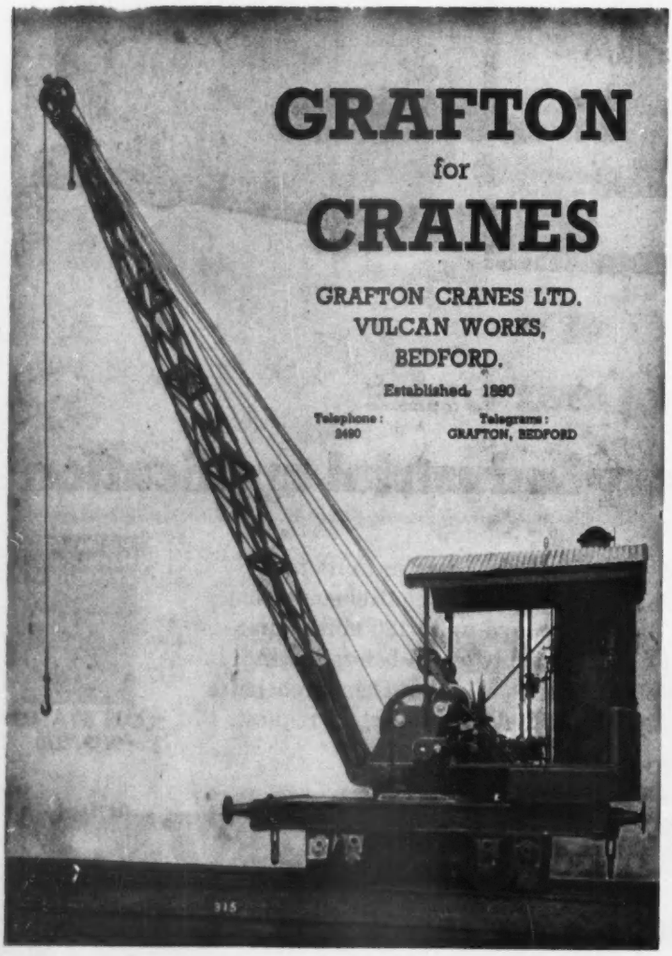
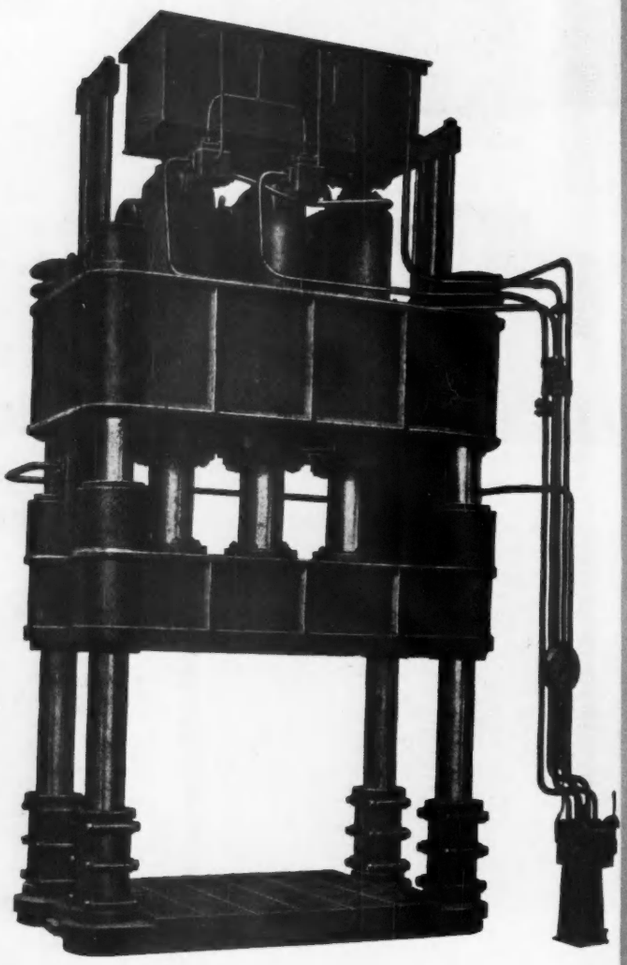


HYDRAULIC PRESSES



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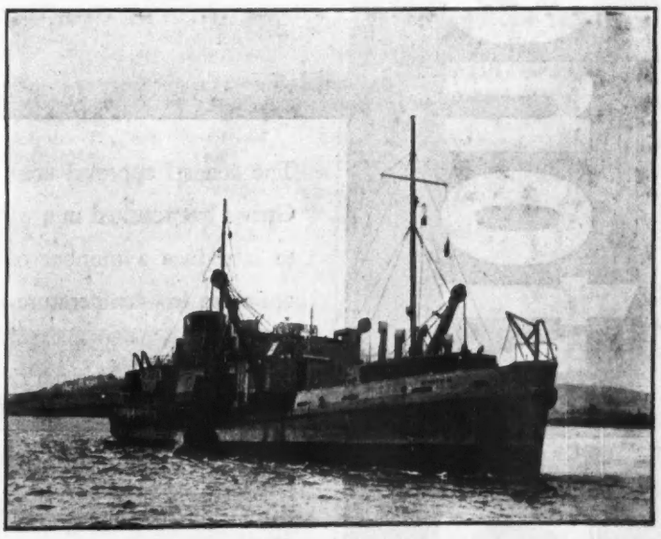

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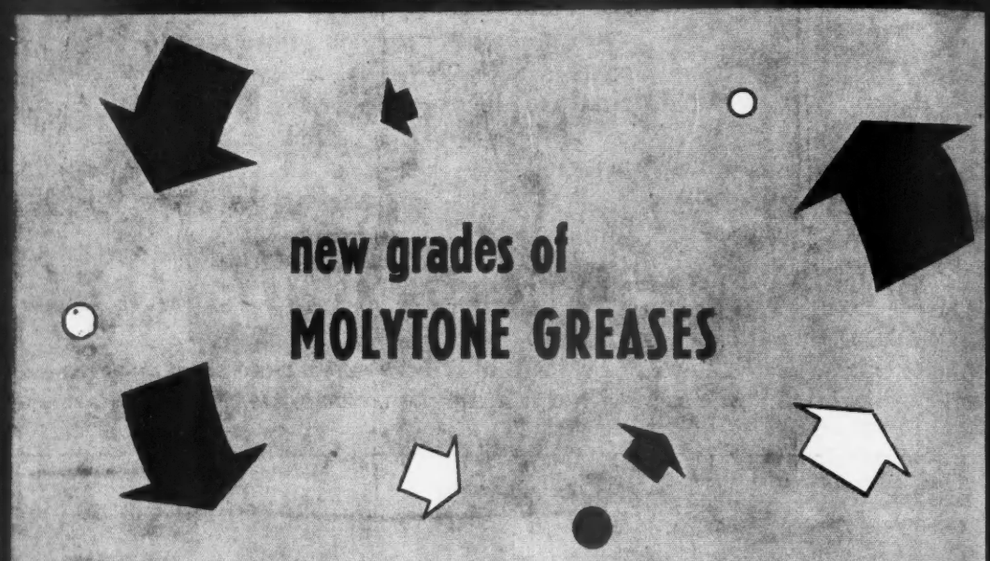

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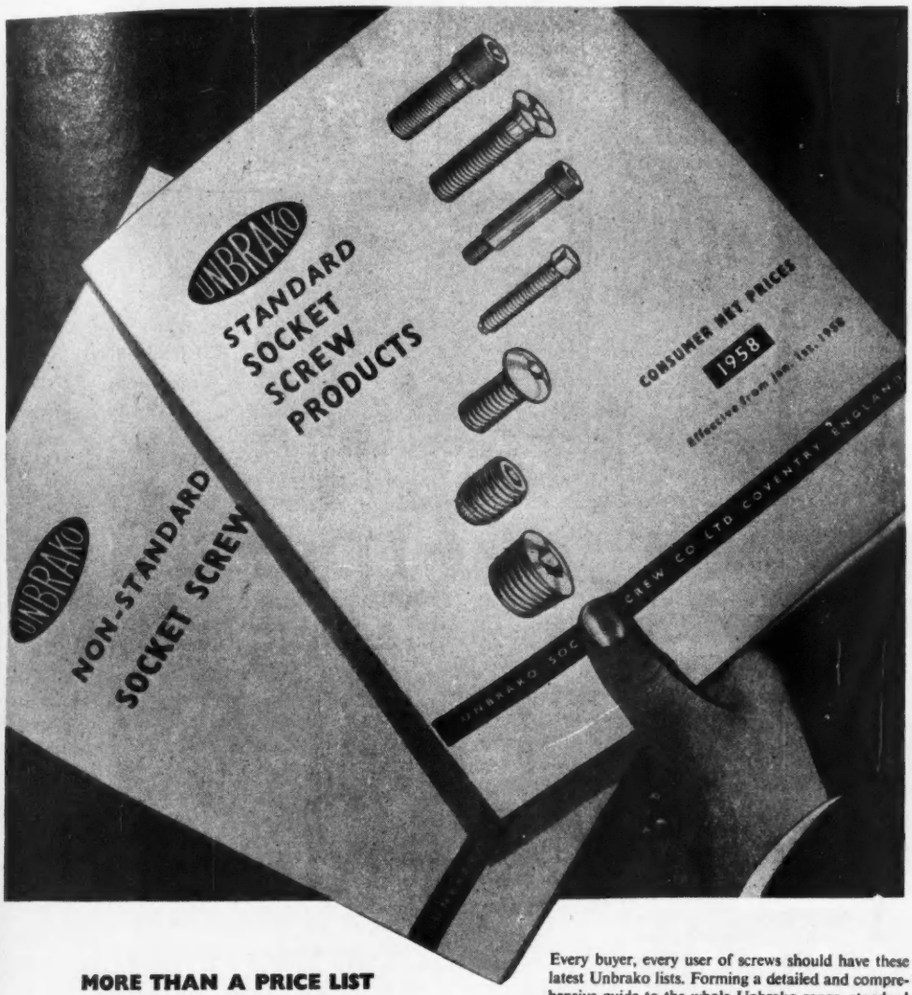

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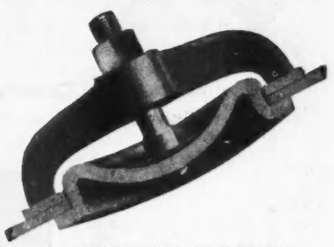

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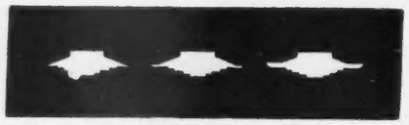

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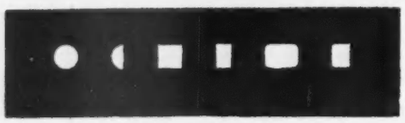

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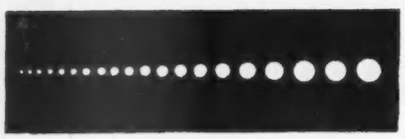

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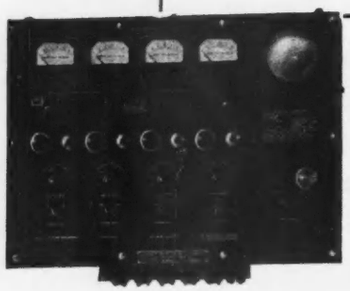

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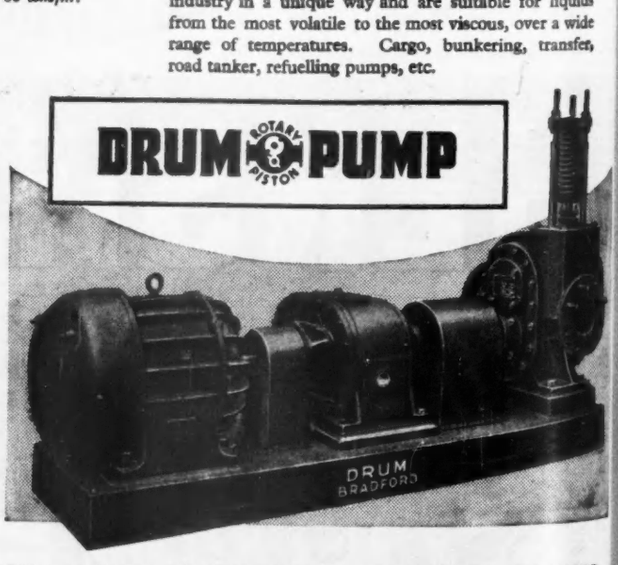

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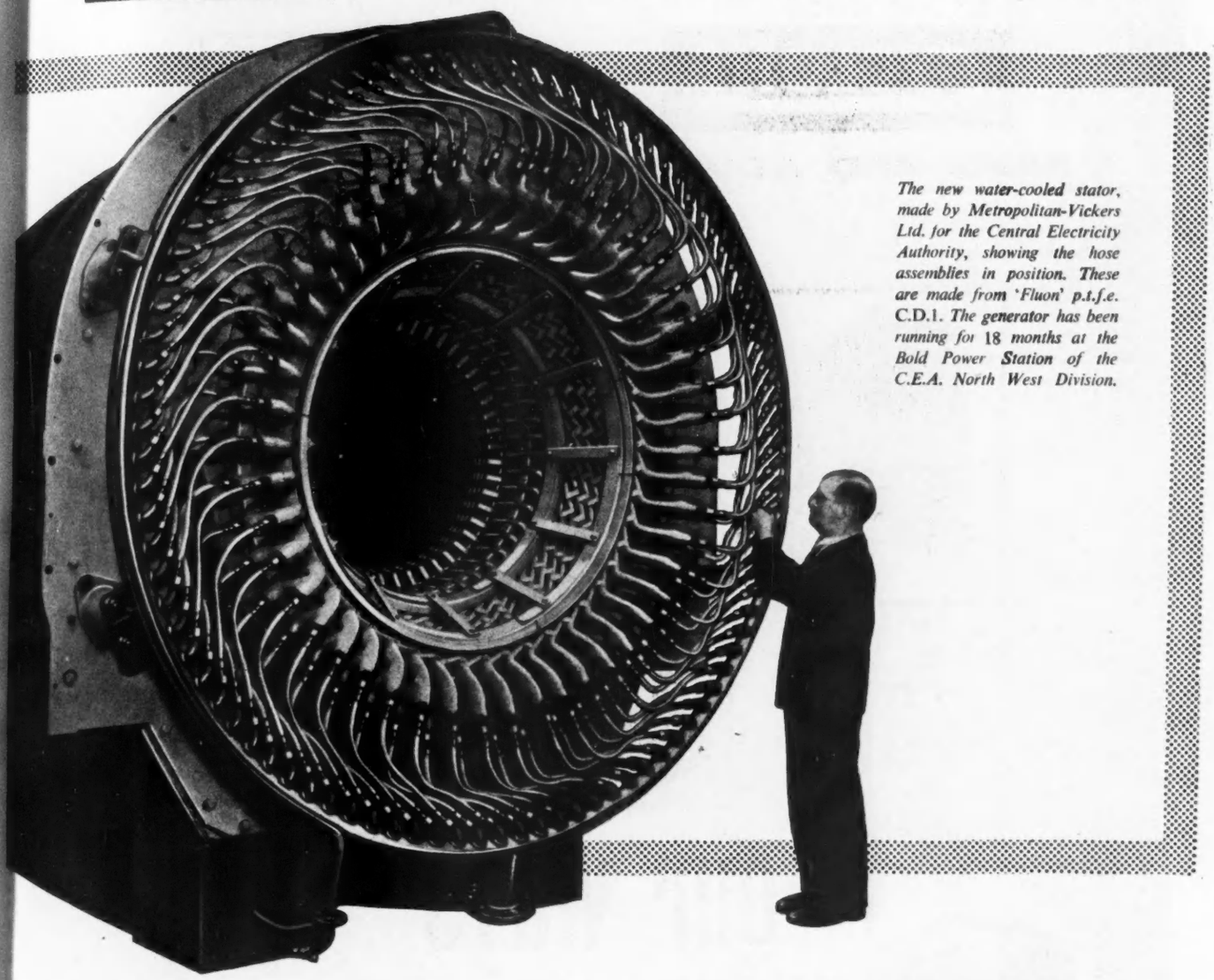

The new water-cooled stator, made by Metropolitan-Vickers Ltd. for the Central Electricity Authority, showing the hose assemblies in position. These are made from 'Fluon' p.t.f.e. C.D.1. *The generator has been running for 18 months at the Bold Power Station of the C.E.A. North West Division.*

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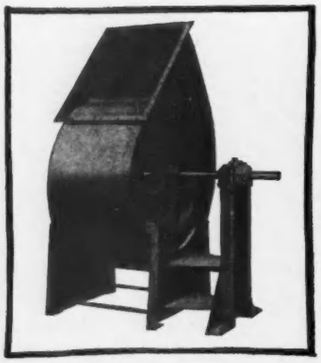

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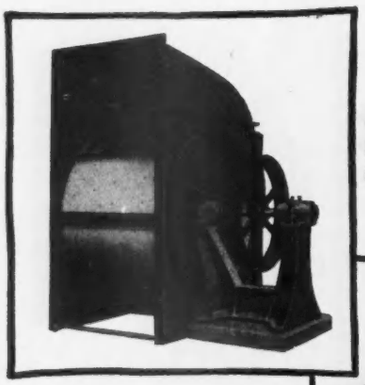

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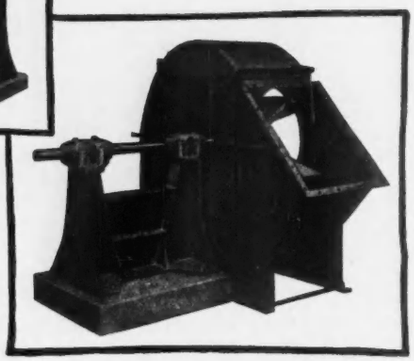

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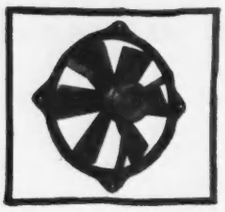

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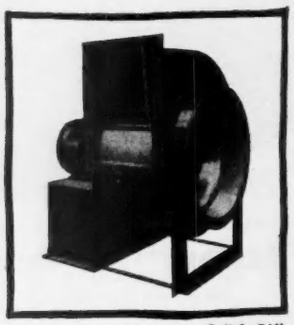

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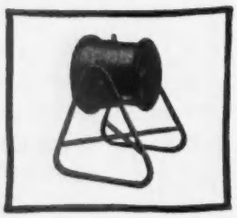

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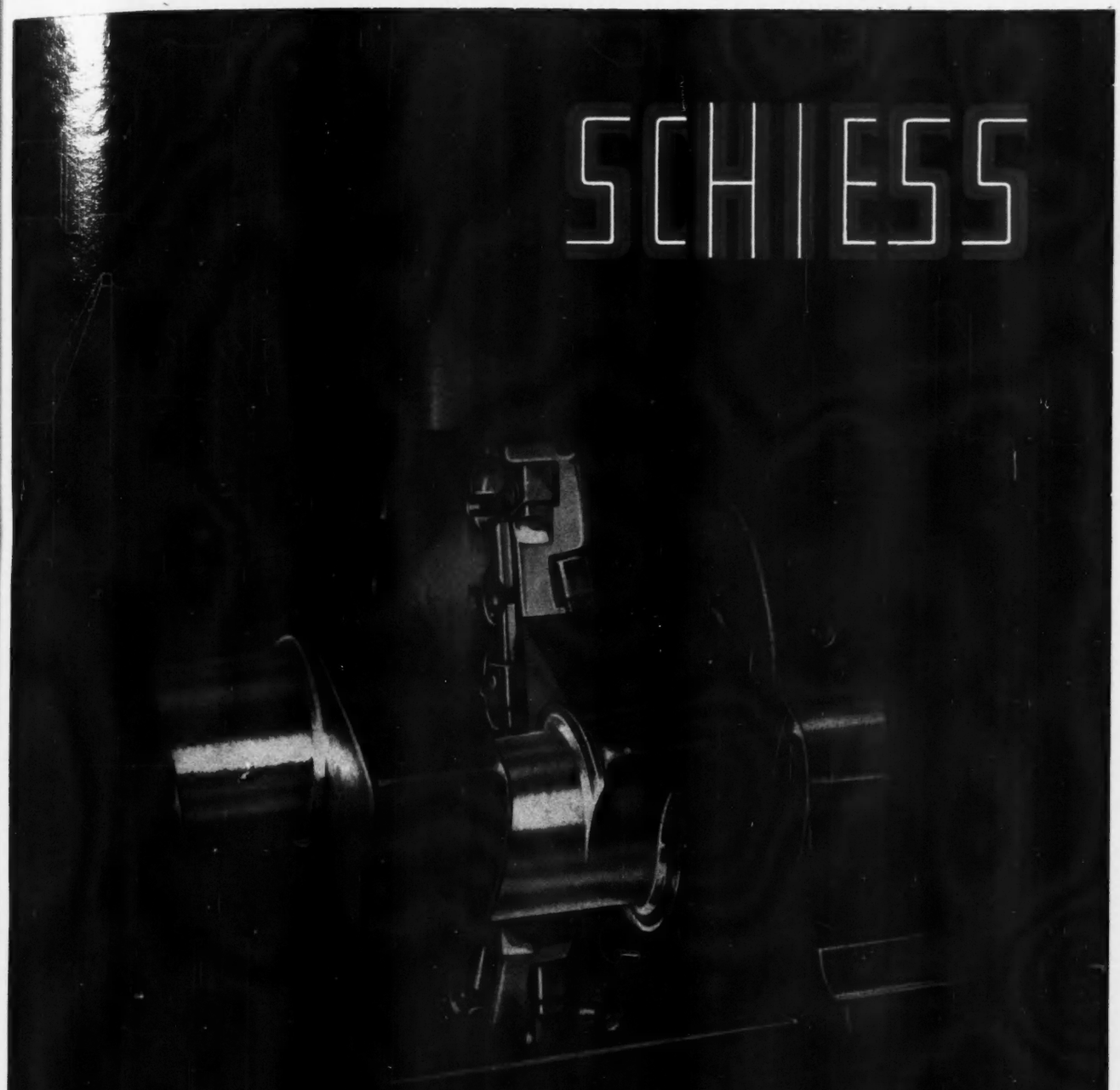

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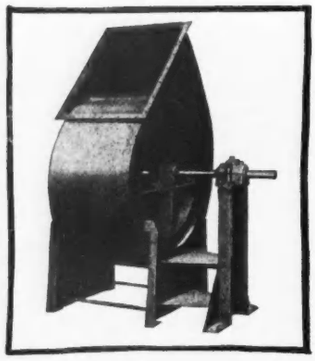
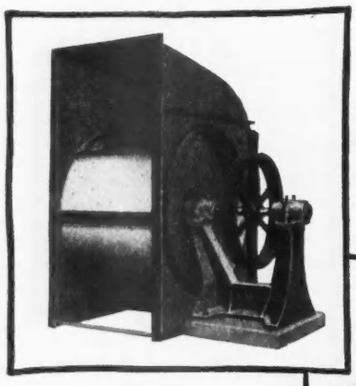


SLOW SPEED MULTIVANE FAN (Intermediate size).



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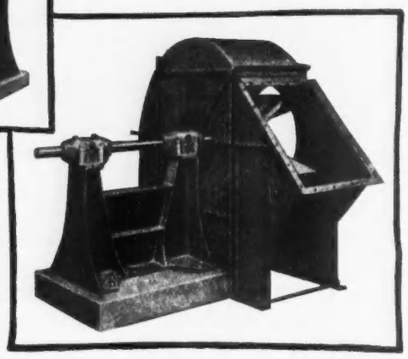
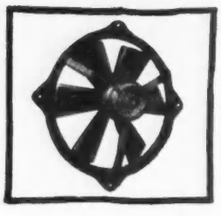


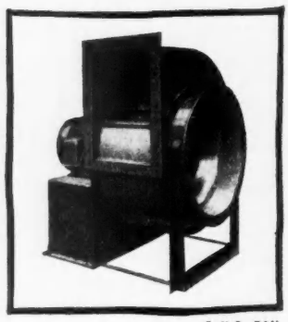
PADDLE BLADE FAN.

are our ways

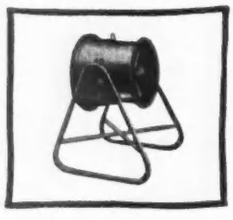
AXIAL FLOW FAN.



PROPELLER FAN.



P.V.C. FAN.



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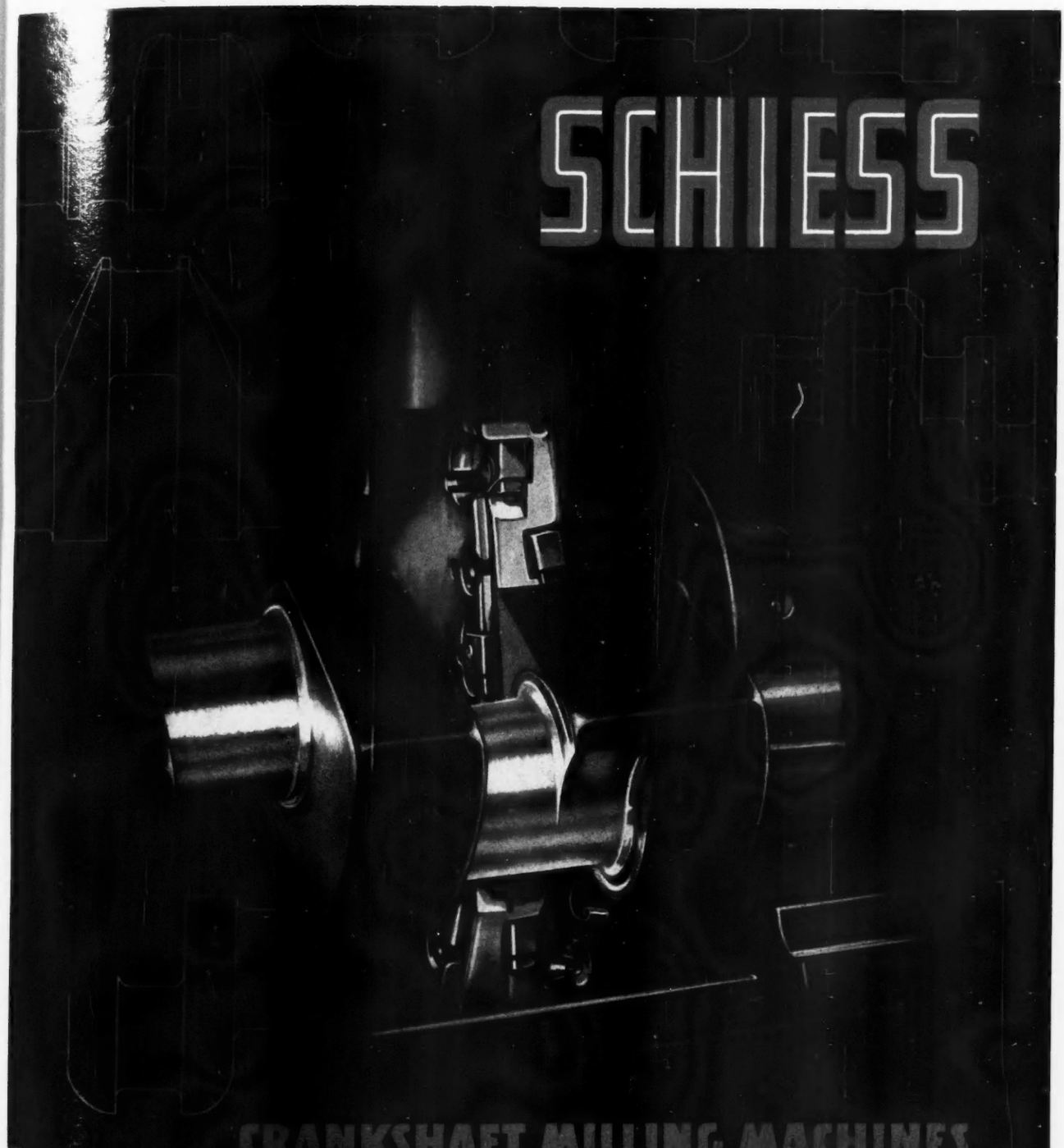

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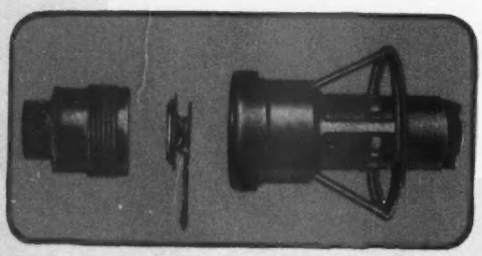

Typical Lockheed-Avery refuelling connections, shown disconnected.

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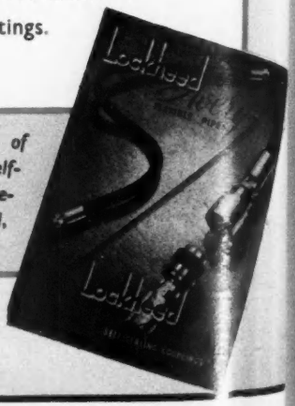

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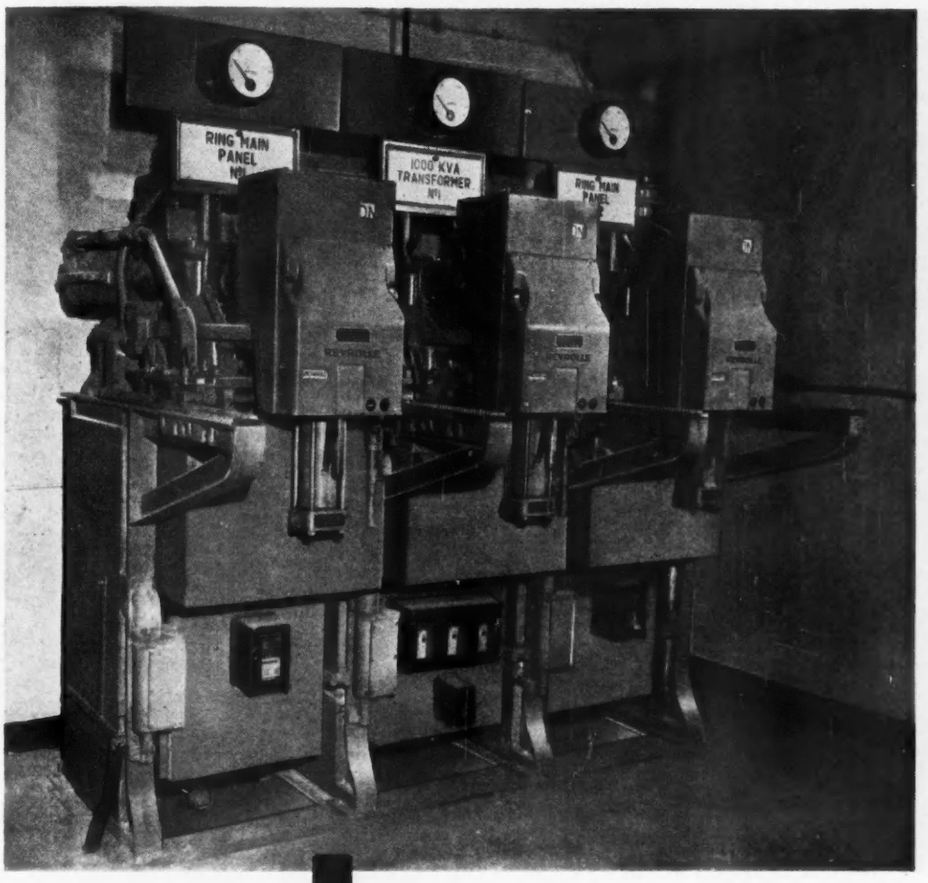

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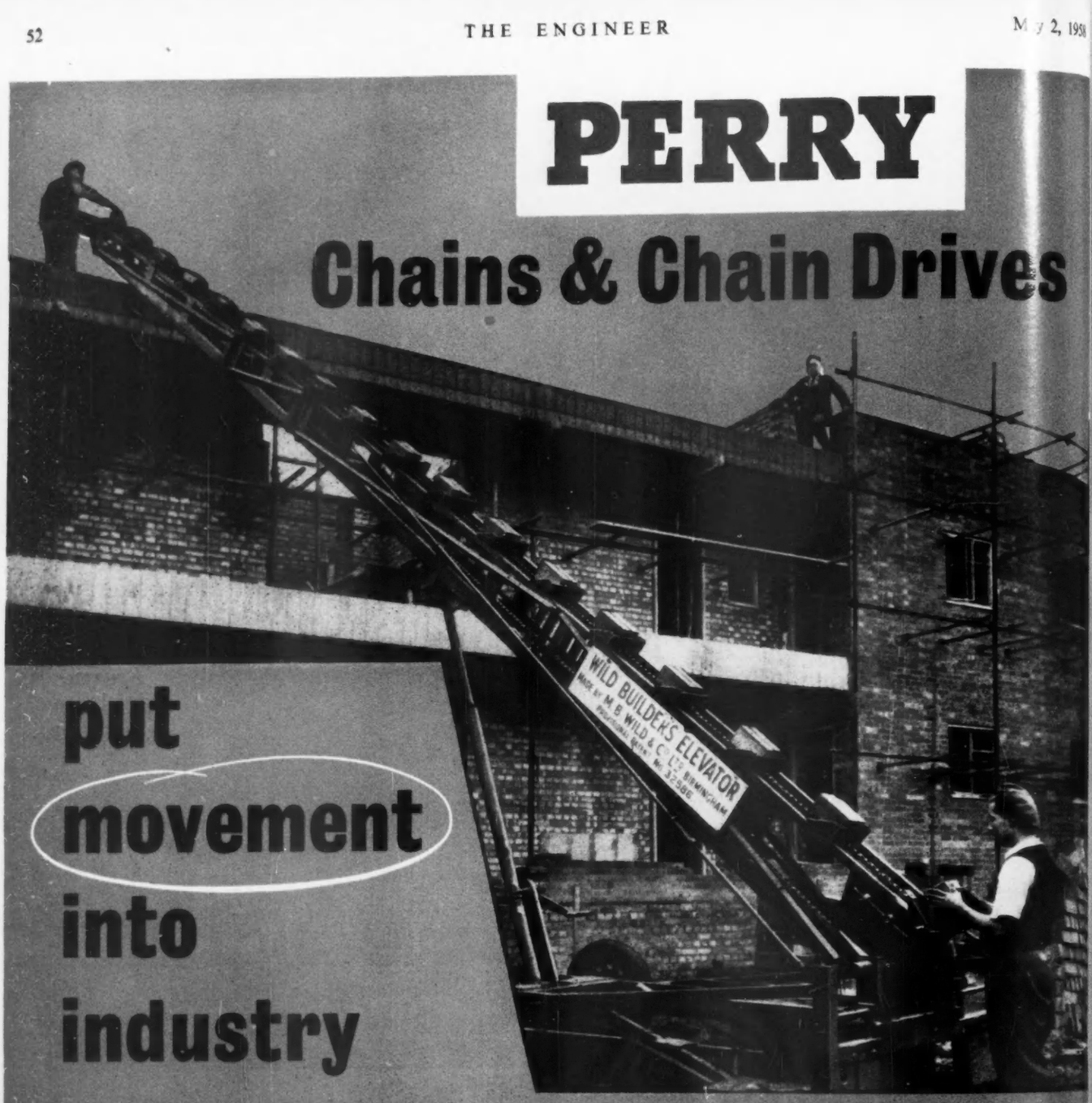

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Stand 271

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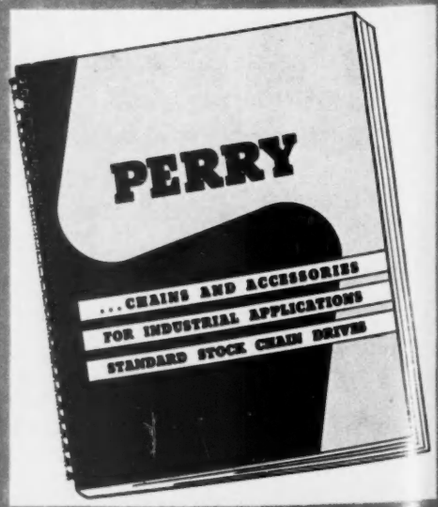

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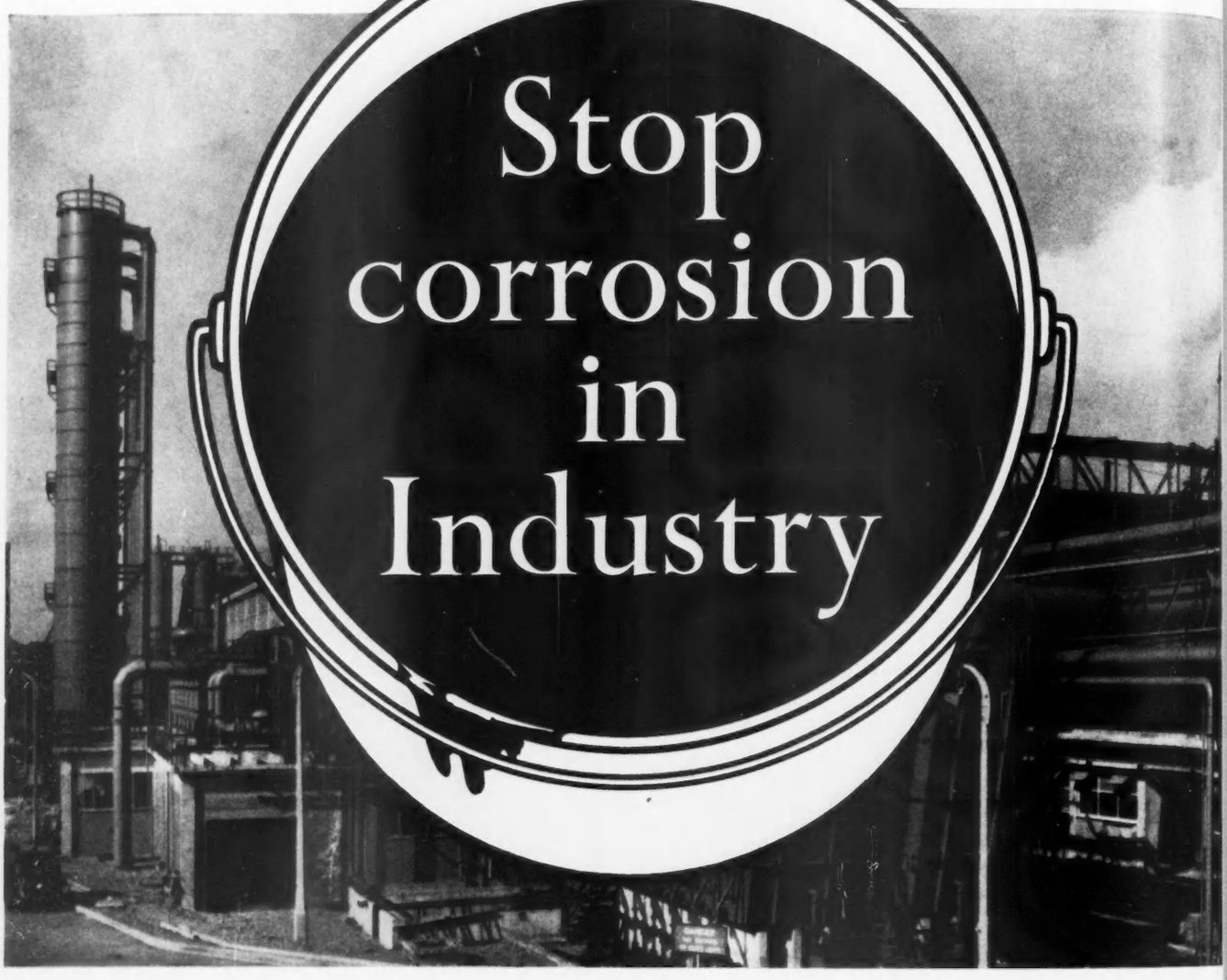

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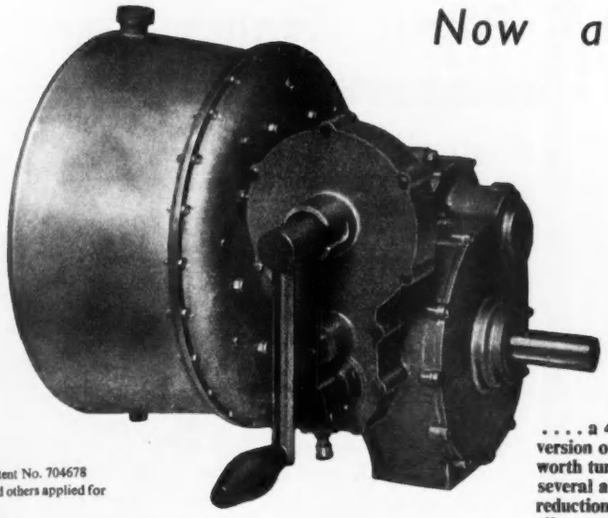

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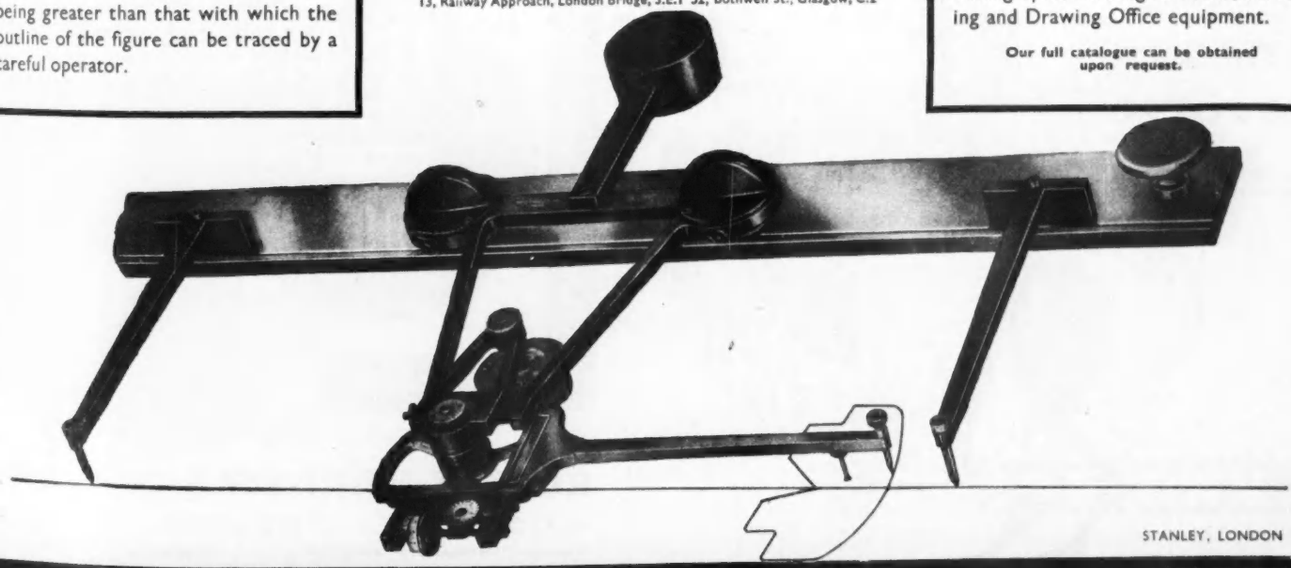

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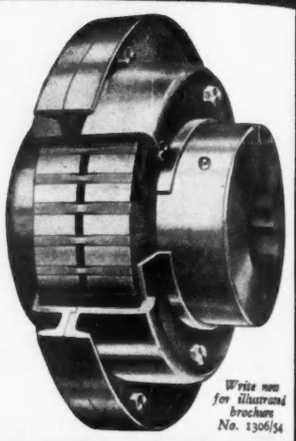

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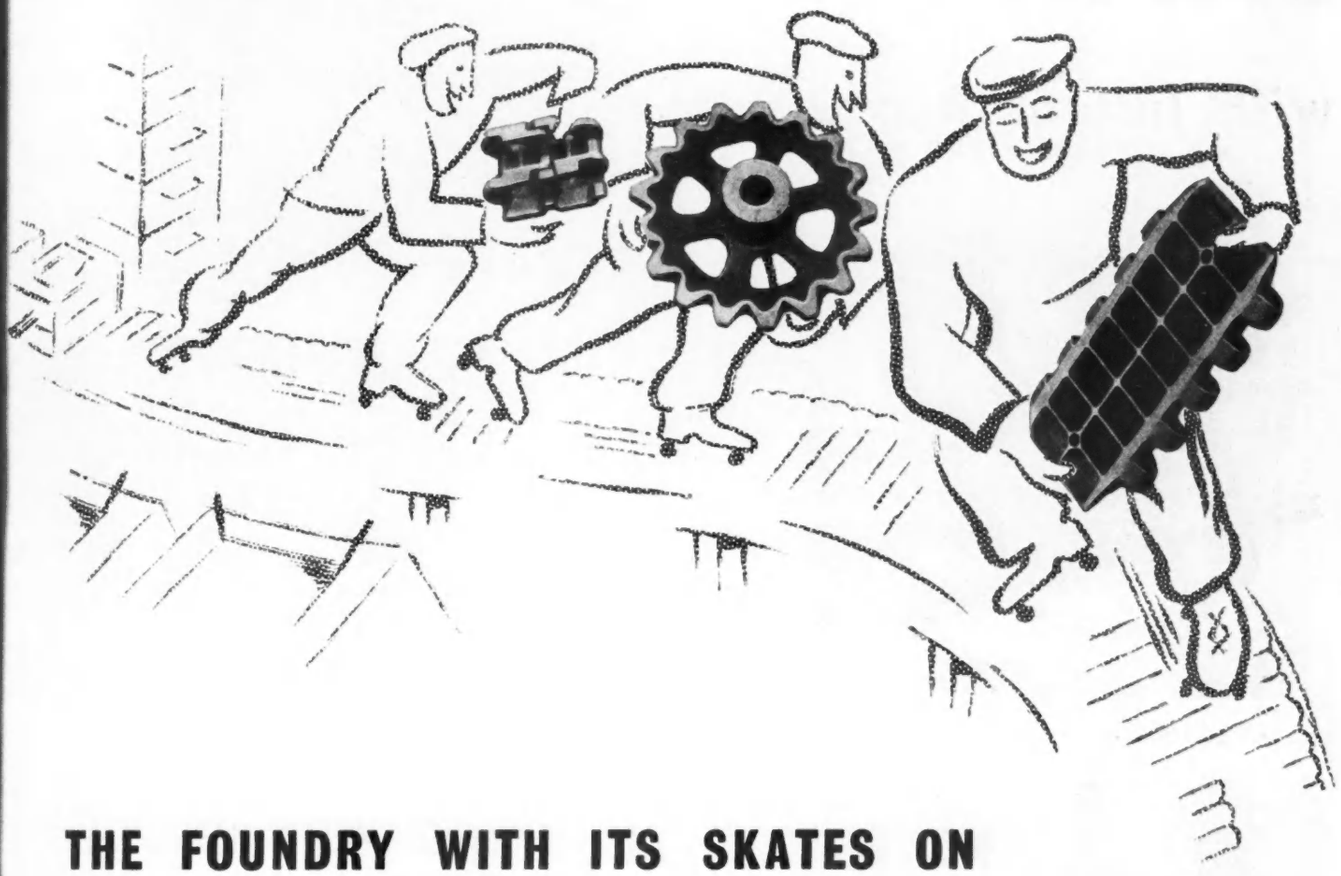

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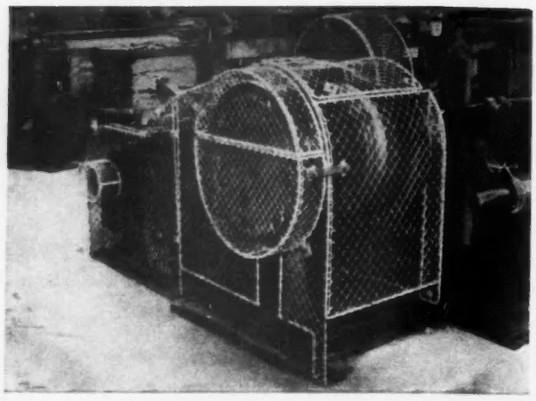

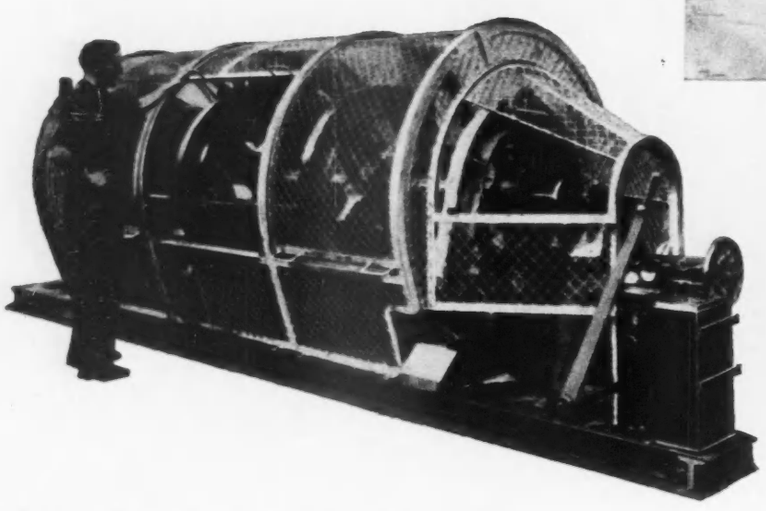

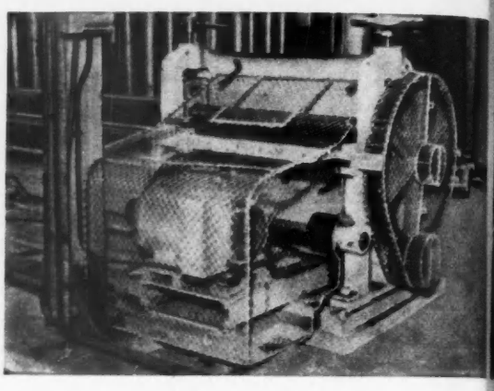

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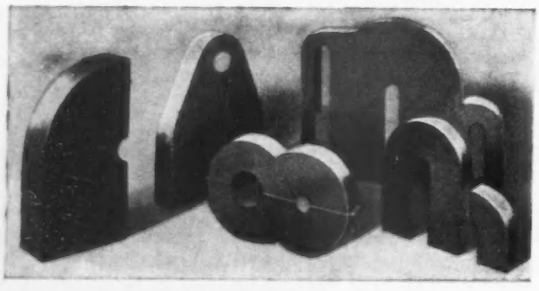

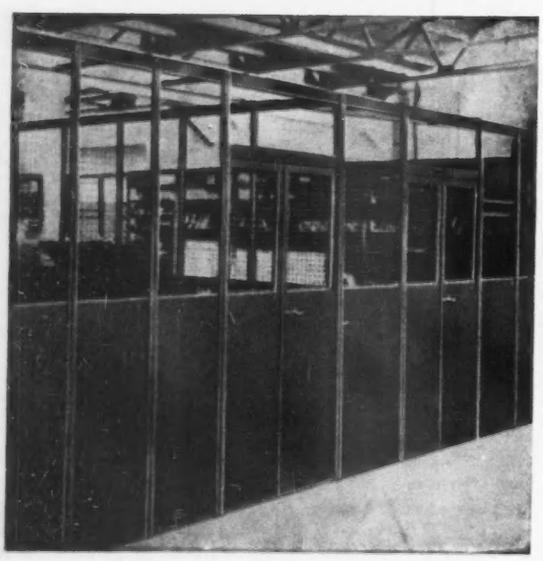

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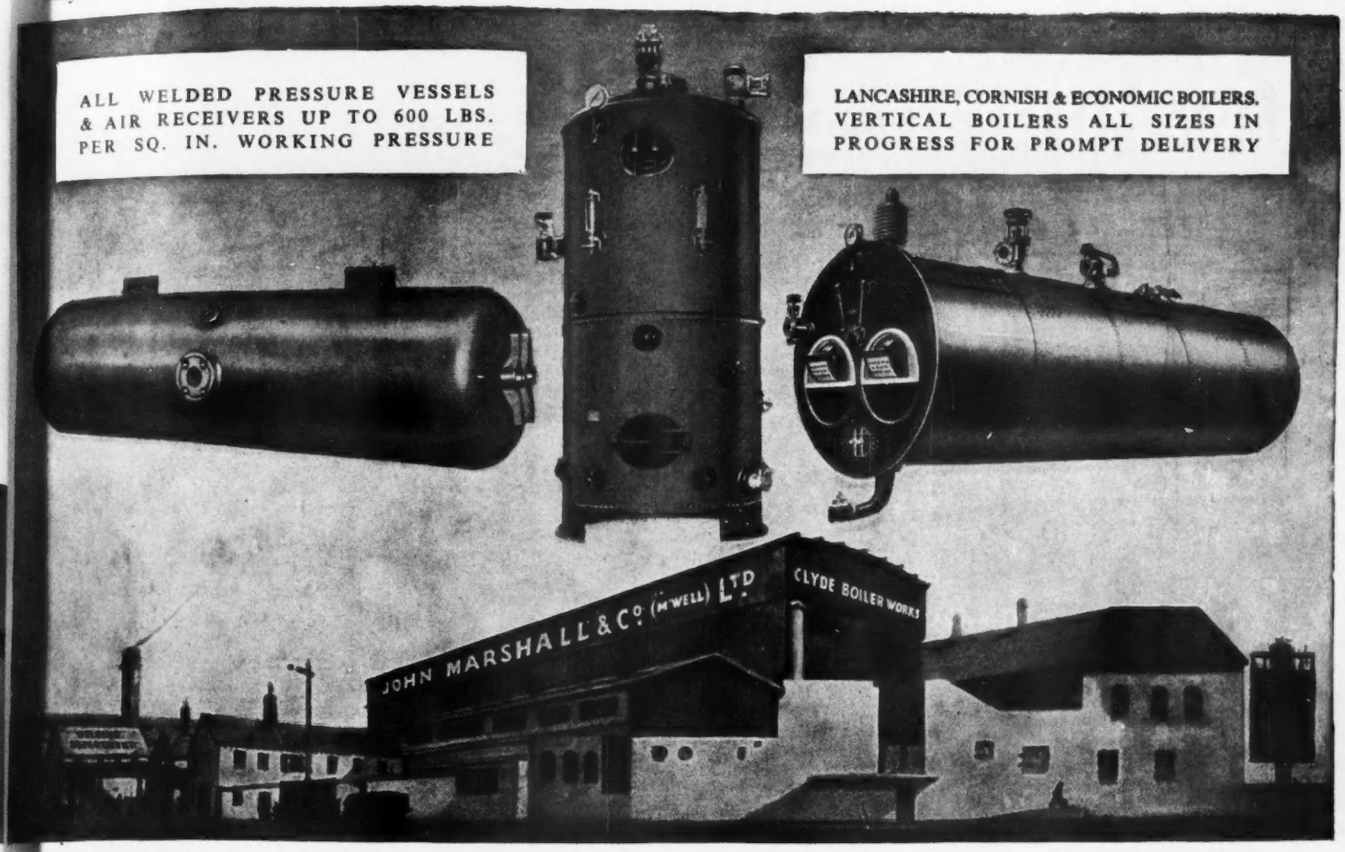
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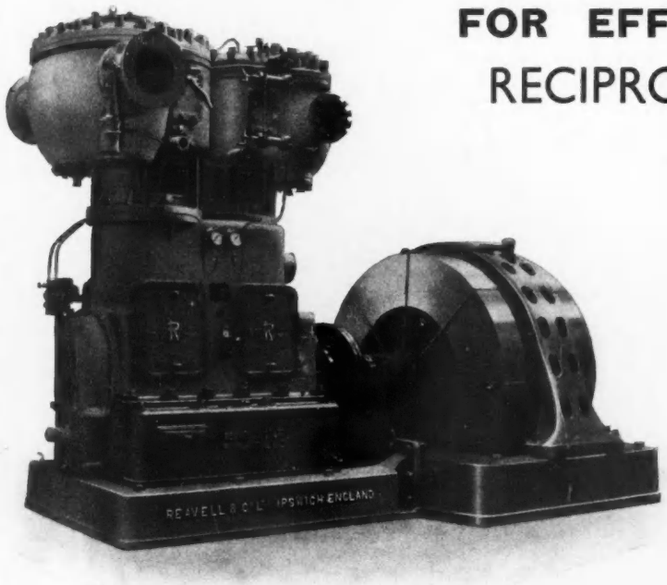

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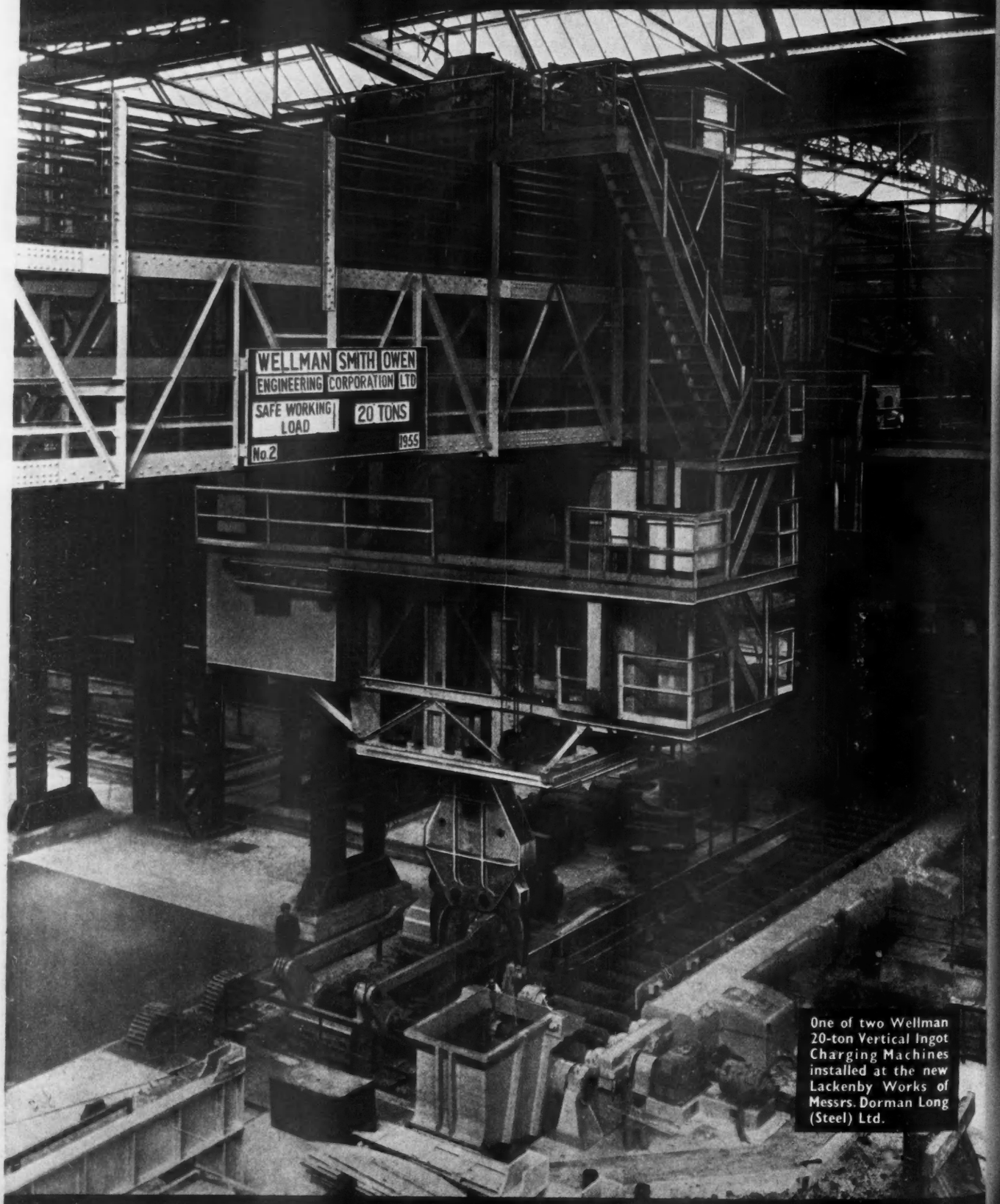

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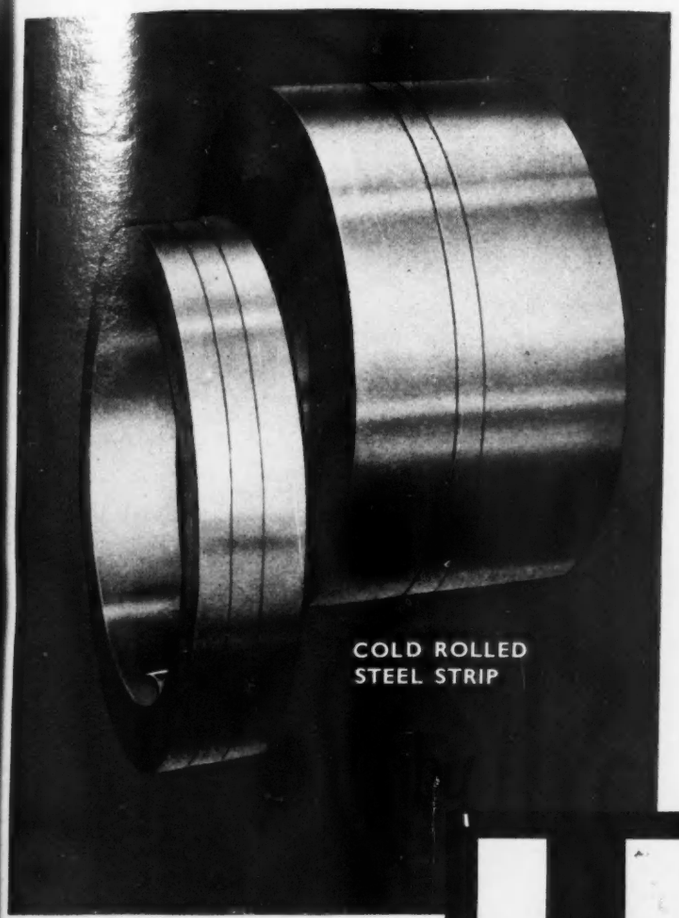

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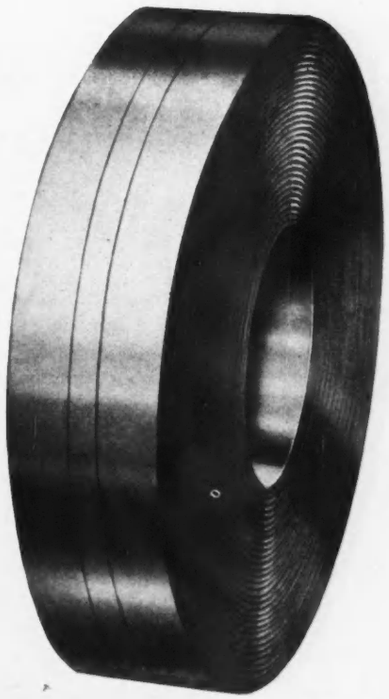

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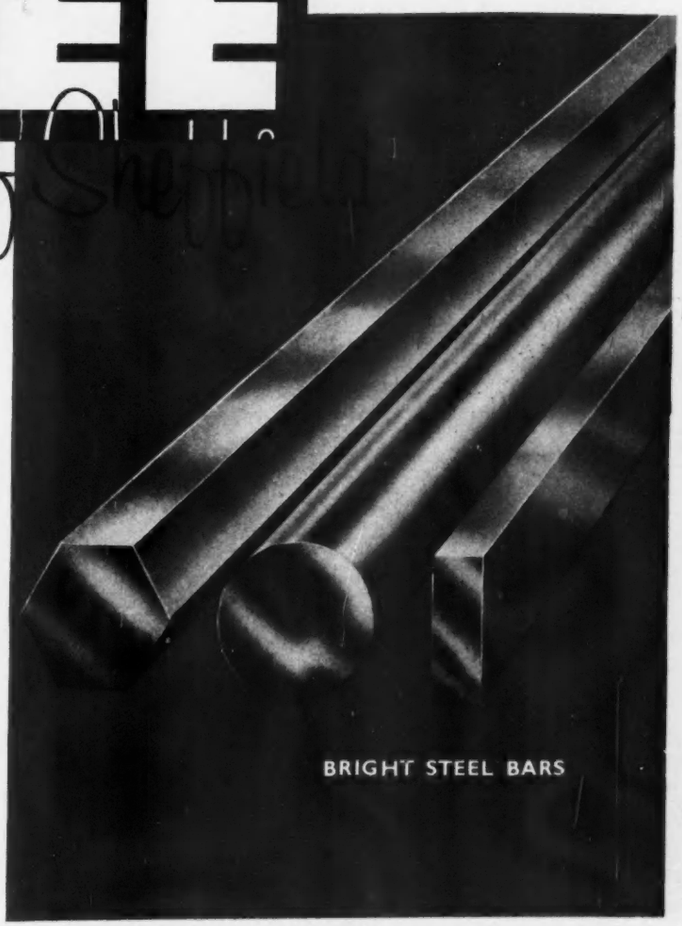

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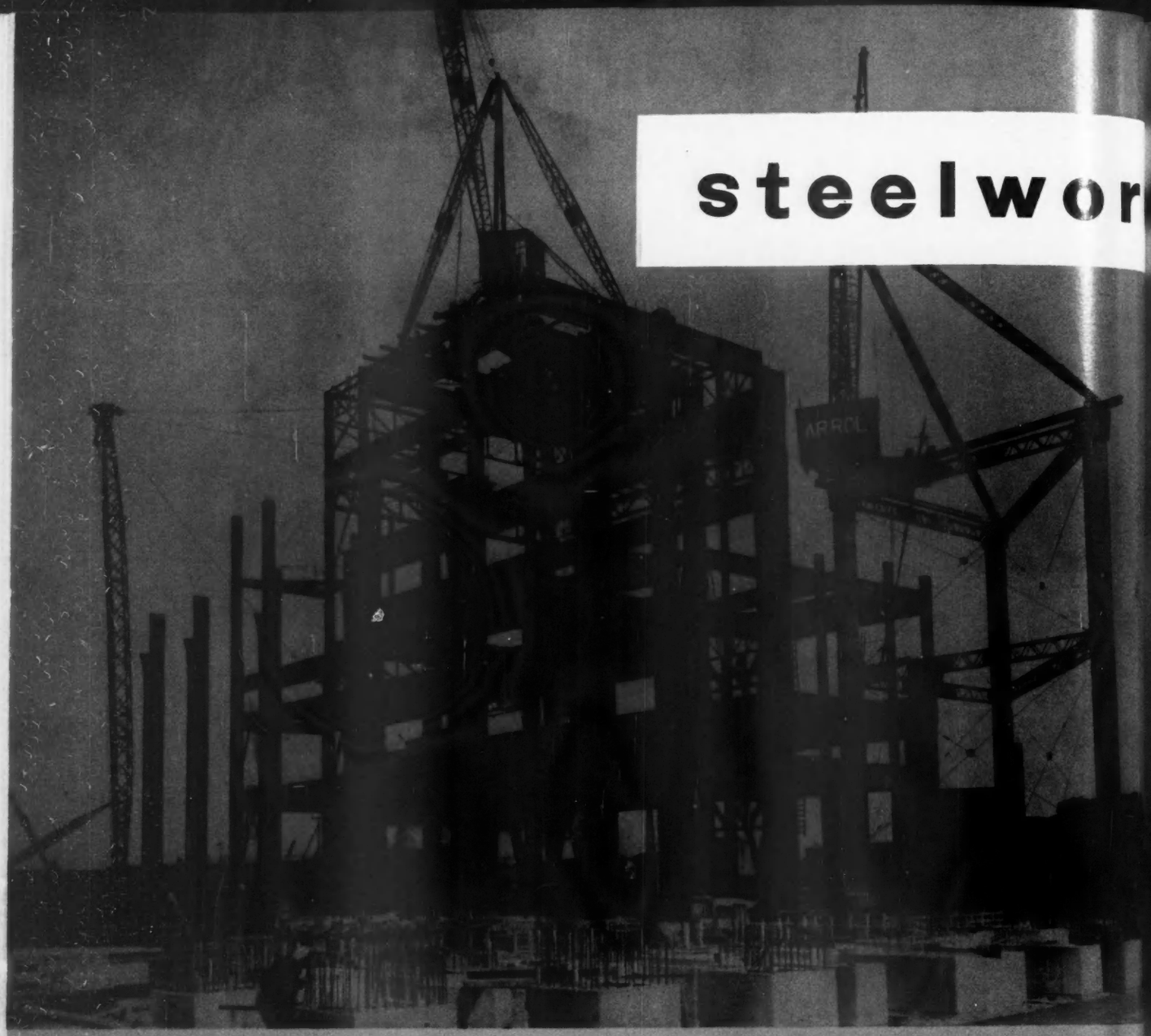

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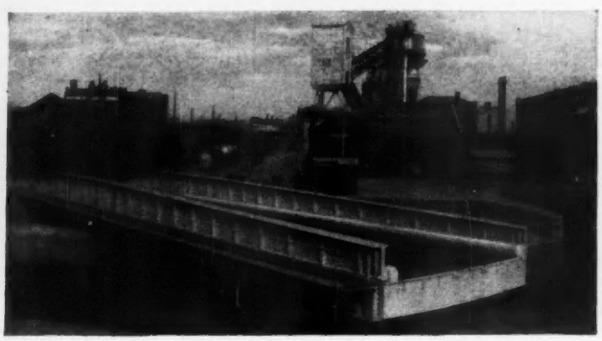

Swing Bridge, Liverpool.
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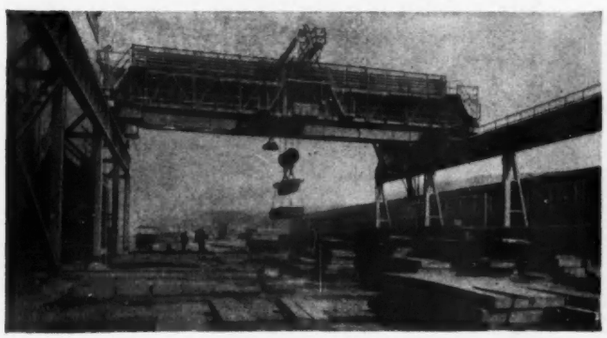

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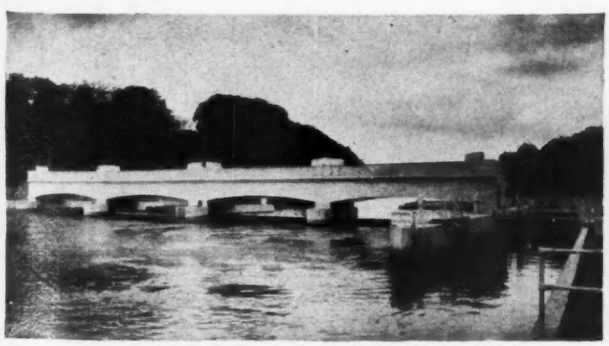
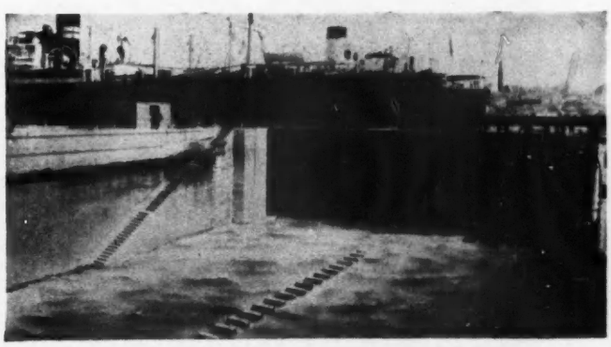


Sluice Gates, Enniskillen.



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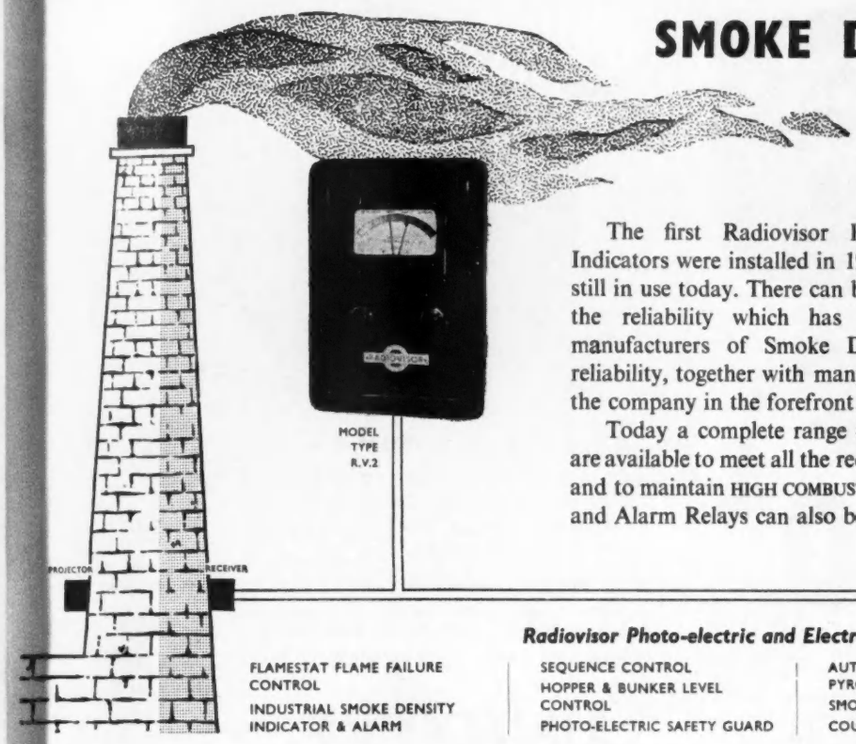

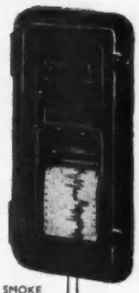

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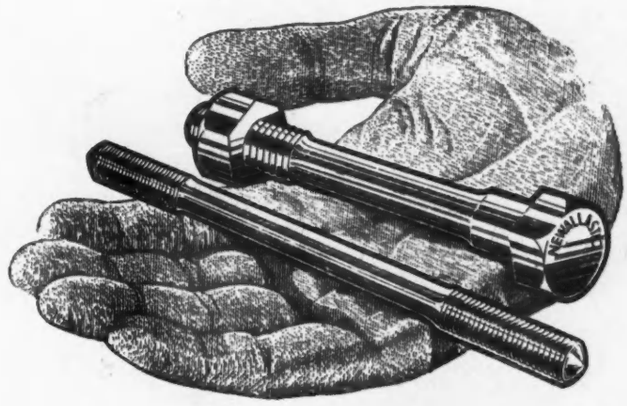

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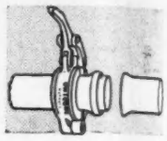
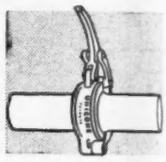


Rubber gasket in position on joint ready to pull over.



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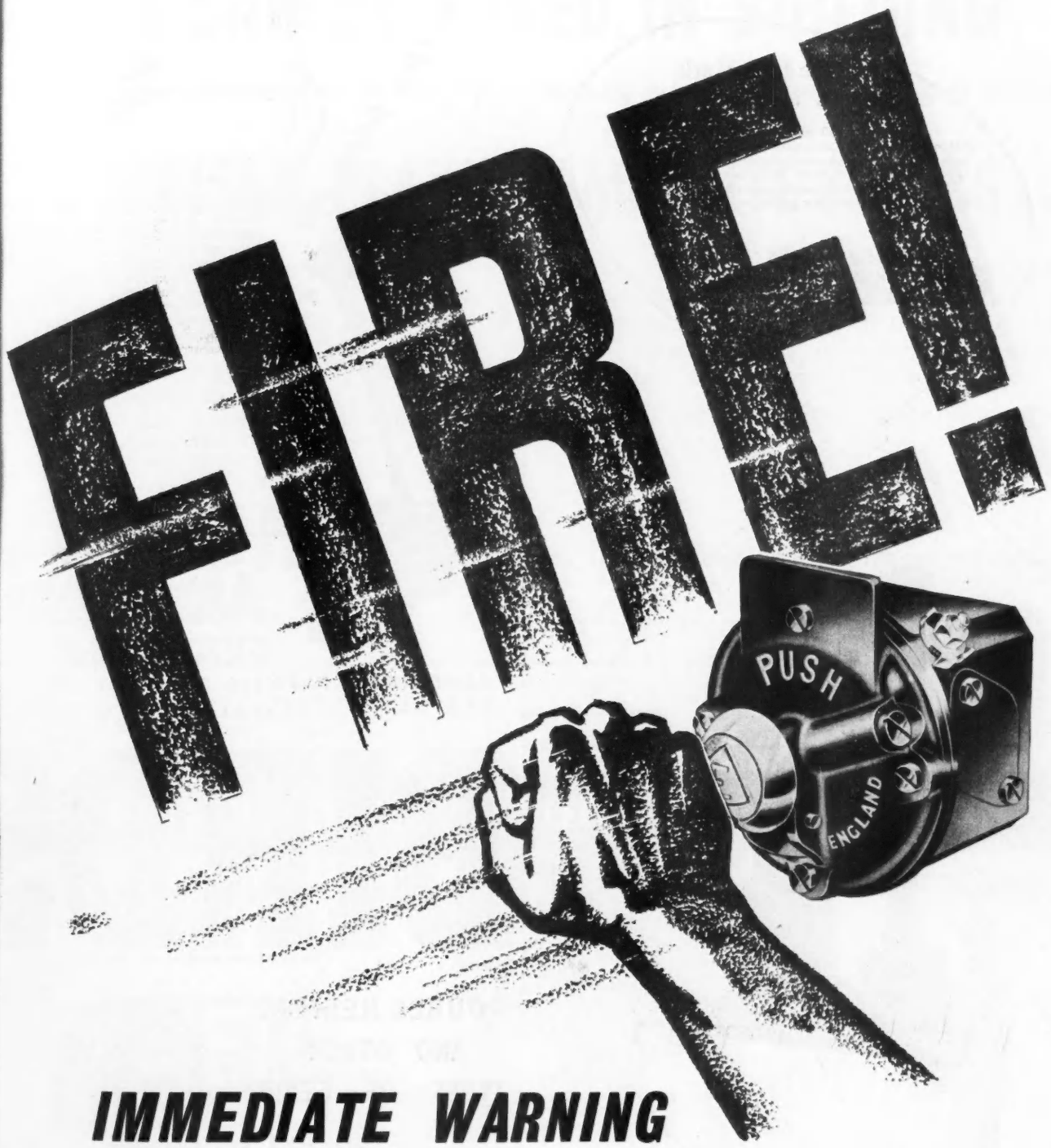

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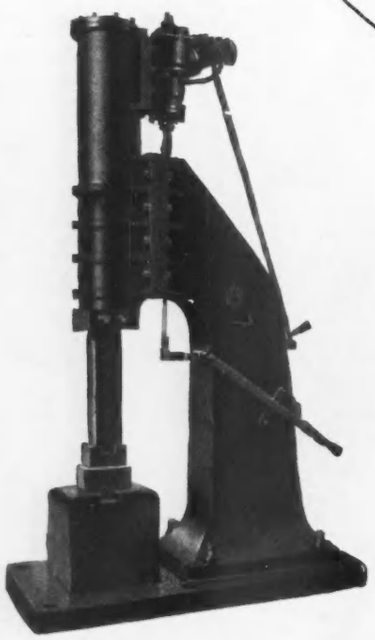

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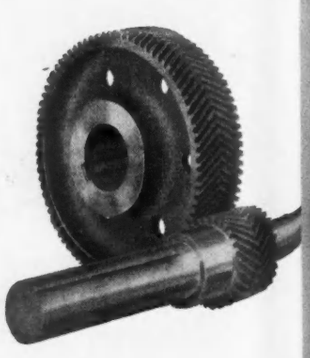

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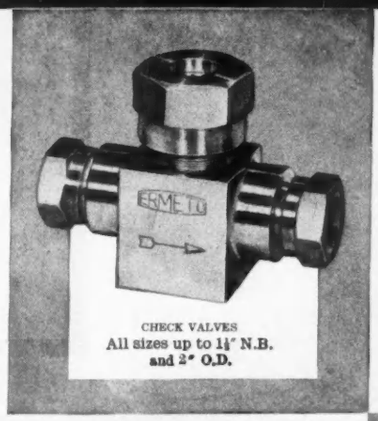

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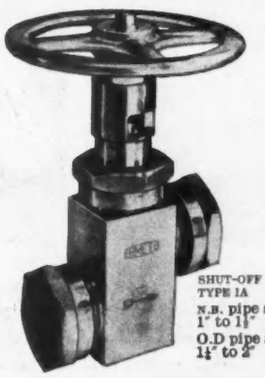

SHUT-OFF VALVES TYPE IA
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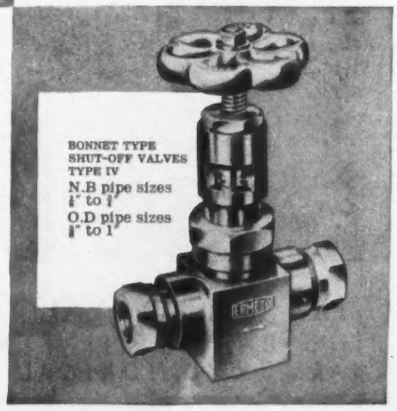

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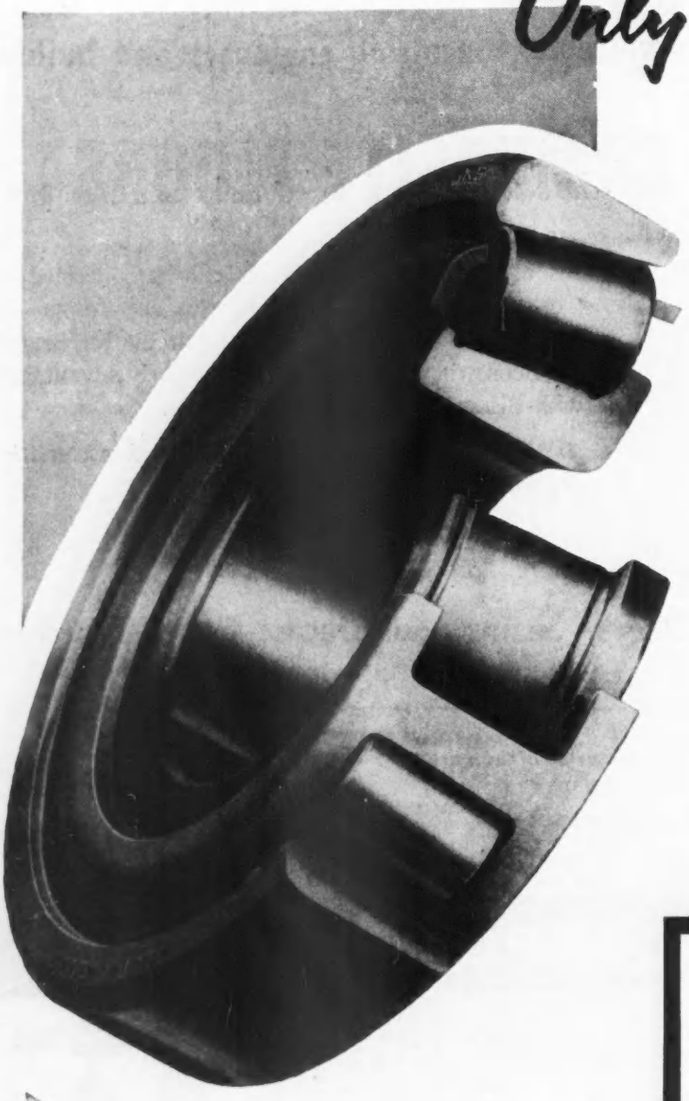

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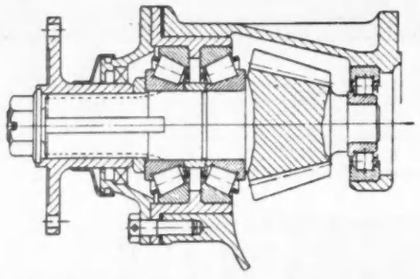
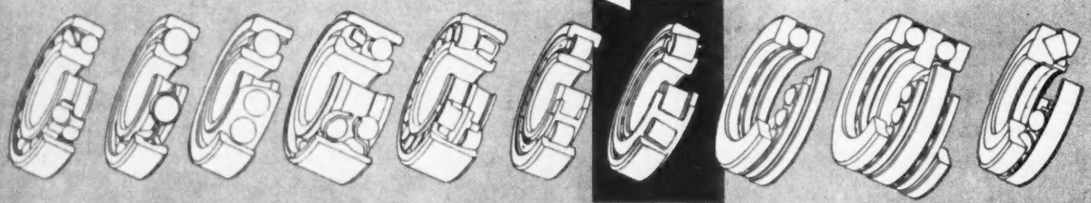


A straddle-mounted bevel pinion for a commercial vehicle incorporating two taper roller bearings and one cylindrical roller bearing



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THE ENGINEER

No. 5336 MAY 2, 1958 VOL. 205

THE BRUSSELS EXHIBITION

Alone amongst the nations represented at Brussels the United Kingdom has failed to some extent to distinguish the difference between an exhibition and a trade fair. No doubt it is this failure to realise that what was expected by the Belgian organisers at Brussels was a cut-down but effective version of the South Bank Exhibition rather than an array of industrial " stands " which accounts for the disappointing scale of British participation in the whole affair. The two U.K. pavilions are both tucked away towards one corner of the grounds instead of being sited (as considerations of the national prestige of a great exporting nation might have dictated) more centrally, like the American, French and Russian pavilions. Both U.K. pavilions are small by comparison with the impressive size of the American and Russian pavilions, and the still unfinished but even larger French pavilion close by. True the U.K. Government pavilion, small and quite unassuming though it is by comparison with those three, is very impressive and effective inside. But unfortunately the rather mean little paved yards into which the visitor is delivered from this pavilion and each of which is intended to illustrate some characteristic of British life fail rather abysmally to maintain that high standard. By contrast the British industrial pavilion looks impressive from outside. But inside so much has been packed into so little space ; there is so little effective balance as between the amount of space accorded to one industry and another ; and so complete is the absence of some of them, that we cannot believe a visitor coming to the pavilion will go away with any really clear perception of the capabilities of British industry. In compensation, however, from two places of refreshment, the " Britannia " and the " Fox and Hounds," close by, he will gain a clear perception of the nature of a British pub ! Is this balancing of relative importance right, we cannot help wondering ? It is disheartening, too, to discover how little U.K. interest has been shown in certain international sections of the fair. In the transport section, for example, where American, French, German, Dutch, Swiss and, of course, Belgian exhibits are quite profuse the visitor must needs hunt diligently to find anything British. We fear the same lack of adequate representation may hold true of the international hall of science in spite of the fact that British representation has been organised by the Royal Institution. For though at the time of our visit it was very far from completely arranged, what little was already on view did not promise any very well-balanced representation of Britain's share in the making of scientific advances. We await the completion of this and other cultural sections of the Exhibition in hope ; but expectant of disappointment rather than the reverse.

Both the Russians and the Americans have grasped, as the British Government did, but as British industry did not, that participators in this international and universal exhibition were expected to provide an offering, subtle or blatant, of propaganda for a way of life, rather than the opening of a shop window. The Russian propaganda is certainly blatant enough ! To enter the Soviet pavilion one ascends a wide and grand stairway ; within its doors one must ascend further stairs flanked on either side by life-size statues on imposing pedestals. Having attained the top, the full length of the hall is displayed before the eyes with, at the further end, yet another flight of steps, having at its head an outsize and dominating statue of Lenin. Within this hall, displayed for effect in a florid and somewhat pompous way, are plenty of exhibits interesting to engineers, from models of steel works and steel works plant to machine tools, motor-cars, tractors and space-rockets. But the whole has a curiously out-of-date air. It does not seem to fit in with this twentieth century. We were teased in the place by a puzzled feeling of familiarity. By and by the penny dropped. Place some large palms around, lay down a red carpet or two, and have some people dressed in gaily coloured uniforms, and one could almost imagine oneself at the Great Exhibition of 1851 awaiting the imperial entry of Queen Victoria ! Was this the kind of impression the Soviets intended to create we wonder ? By utter contrast, though presumably it is intended as propaganda, it is rather difficult to understand whether the Americans are trying to convey anything at all in their pavilion close by ! It is circular in shape and, unless an architect sets out deliberately to create some other point of emphasis, the most important site in a circular construction must lie at or near its centre. The Americans have placed a circular pool of water in the centre ; upon this pool there floats a " landing stage " connected by a gangway to a gallery round the building ; and up and down this gangway—apparently all day long—models parade displaying the latest thing in American feminine fashions ! This is all so different from Lenin's dominance of the Soviet pavilion that Russian visitors must find it a very confusing representation of American achievements and the American way of life. Even the Western visitor takes time to discover that to see more technically interesting exhibits he must penetrate into semi-enclosed spaces and rooms arranged around the circumference of the building. Just as with the Russian building we rather wonder whether the Americans have succeeded in creating just the effect they desired. Have they ?

Subject to whatever it is that the French are going to put on view—our sympathy is with them, for unexpected foundation troubles delayed the completion of the structure of their pavilion—it seems to us that it is the smaller industrial nations that have really stolen the show. Belgium, of course, as the host nation has had plenty of space adequately to convey the extent of its industries. Amongst particularly effective halls, that covering electrical energy and water power needs particular mention ; and amongst structures the Atomium—though we poked some fun at it in our issue of November 8, 1957—turns out, largely because of its great scale (so that it has become a landmark for miles around) and its polished ability to reflect

the sun, to be a very impressive centre-piece. But, with much less space to play with, the Swiss, the Dutch, and from the far side of the Iron Curtain, the Czechs, have all found particularly effective means of expressing national characteristics and displaying technical achievements. They have, of course, special advantages. For, as compared with bigger industrial nations, they have a lesser range of products to display and thus, even in a limited space they can more effectively display them. It is however to be observed that in proportion to population these nations appear to have spread their exhibits over a larger area than British industry.

But are these great international affairs really worth while, we were driven, footsore and weary after each day at the Exhibition, to wonder ? Alone amongst the nations, as we have already remarked, Britain seems to have regarded participation in the Exhibition as a business, rather than a propaganda, proposition. No doubt that is why the British industrial pavilion reminds one of a trade fair at, say, Olympia, whereas the pavilions of other nations at Brussels call to mind something more like the South Bank Exhibition. British industry, it is obvious, is not much interested in putting over propaganda for the British way of life ; it is more interested in sales ! But perhaps it is the right attitude to adopt. Minorities, even minorities of one, can be right. Do these international and universal exhibitions really justify the expense lavished upon them ? For if they are not to be regarded as trade fairs then presumably they can be justified only on the grounds of increasing the understanding between nations. Significantly, entering the Exhibition by the Porte Mondial one goes immediately through the Hall of International Co-operation ; and U.N.O., the Council of Europe, the European Coal and Steel Community, Benelux and other international organisations are all represented, several with halls of their own. International co-operation is therefore the theme of at least part of the Exhibition. But what we wonder—in relation to the vast expense involved—can such exhibitions do which cannot be better done by encouraging tourism and international trade and through the wise use of air travel and the television screen ? There is therefore certainly something to be said for the British attitude. If these great international exhibitions must be held and if for prestige reasons Britain must be represented, then industrially let us forget propaganda and go flat out to get what business we can. Propaganda can be left to our Government. Maybe it is a policy which lacks idealism. But it may nevertheless be a realistic appraisal of the worth of such exhibitions.

PUT IT THERE !

Even those engineers who believe that future advances in automobile construction will come by refinement of existing designs—as has been the practice in this country ever since large volume production became established—rather than by far-reaching revision to reduce to insignificance the present limitations on performance, will study with interest the progress of petrol injection as reflected by such reports as those in this and our last issue. While fuel injection, like so many other departures from conventional practice, ideally requires a vehicle to be designed from the start to employ it, there is good reason to expect a significant improvement in usable power, if nothing else, when it is applied to existing engines. And it is quite clear that more power is still sought by designers in this country. To-day, it is only on the Continent that four-seater cars of high performance are fitted with engines as small as 850 c.c.; and our 1500 c.c. class no longer contains the fast six-seaters that were our pride five years ago. The use of larger engines commends itself to the transmission designer and the maintenance engineer, but it is a poor solution in vehicles where the engine weight does not rest on the driven wheels. How attractive the approach of widening the working speed range of the engine may prove can be judged from the Jaguar experience. An engine that, carburetted, needs four gears or three gears and a torque converter to handle a medium-sized car became tractable throughout the speed range when tuned to give 300 h.p. with manifold injection.

The papers and comments at a recent symposium render it hardly possible to doubt that positive distribution of the petrol will overcome such fundamental limitations as are imposed by Mach number in the carburetter and acceleration round the manifold, and will allow vehicles to be built with lighter engines, lighter transmissions or lighter fuel bills. But it remains debatable how soon cars with such improvements will be saleable. For they will cost more. To what extent (if at all) do users really weigh lower running costs against higher first cost in cars otherwise almost identical ? However, we believe that many of the contributors to the discussion were unreasonably pessimistic in their comparisons with the supposed simplicity of the carburetter. A study of the invaluable appendices to the address of Mr. Errol J. Gay shows that petrol injection engineers are still confining their attention to systems in which the fuel pump supplies the energy to atomise the spray and, except in the one electronic system, to open the nozzle valve. The relatively extensive experience that has been gained in the building of heavy-oil engines shows that such systems comprise but one class of equipment and not that associated with extremes of performance. Injectors can be driven hydraulically, although to do so appears to be attractive rather on very large than on small engines. On a four-stroke engine there is little difficulty in installing a mechanically operated injector, such as is associated with the endearingly subtle " Pressure/Time " system ; and pneumatic, or blast, injection should, it seems to us, certainly be studied for handling a volatile fuel. Thus, it hardly appears that all possible techniques have yet been exploited fully, while the comparative ease of injecting into air that has not been increased in density many times, as in the diesel, should give further scope for new methods that may reduce radically the disproportionate capital cost of injection systems.

In one respect the work reported is disappointing. It appears that understanding of the kinetics of compression and combustion processes is still inadequate to encompass a satisfactory high output stratified charge engine. It appears that the lion's share of the work on this attractive concept has, since the abandonment of the Jameson engine, been done on the Continent. Certainly the task of evolving such a cycle could be undertaken only by an engine manufacturer of very great experience with a wide market for his products—it would be no more than prudent to consider the possibility of sleeve or rotary valves in place of poppets, for instance—but the application for which it would be required (in vehicles which spend much of their time far from the design point and yet need good peak performance) appears likely to remain in demand for long hence. The prime mover which already boasts an inherently efficient cycle, the compression ignition engine, is, to judge by a study of its latest representations, still separated by many years of much difficult engineering

from being able to compete in both performance and cost with the small petrol engine (except in the taxi, where running cost predominates), despite the comparative cheapness of the single-cylinder injection pump with a distributor.

SHORTER WORKING WEEK

In the days of our grandparents' youth, men worked twelve hours a day, six days a week, in order to experience a standard of living miserable by comparison with that ruling to-day. Since then hours of work have progressively been lowered. There has been almost continuous pressure from trade unions for reduced hours of work and almost continuous resistance from industry on the grounds that the reduction of working hours really means an increase of overtime earnings. The pressure for reduced hours persists. In his presidential address to the 1958 National Committee of the Amalgamated Engineering Union last Monday Mr. Carron had some words to say on the matter (though not, curiously enough, about wage rates). "We have never," he said, "had a case to put which is based so firmly upon a solid foundation of truth, justice, logical reasoning and fair-mindedness as that which forms our present application for a reduction in the standard work week. . . . . The 40-hour week, delay it how they will, is something which the employers must surely recognise . . " He is, of course, right. As man's productivity rises—largely through the inventions of engineers—it becomes essential, if only to make it possible to sell the product, to pay more in wages for fewer hours worked. In the past, maybe, there were only a few industrialists who appreciated that point. Henry Ford was one of them. But nowadays there is scarcely any need for the unions to make it. All that divides managements from unions to-day is the factor of timing. Throughout the engineering industry to-day more highly productive methods are being steadily introduced. At what stage does it become desirable to reduce working hours so as to benefit both men and management ? Certainly not, surely, when there is much overtime working in order to meet demand ? Then should it be when demand is relatively slack so that full time is only just being worked ? In either case it is to be observed that the effect must be equivalent to a rise in wages and thus unwelcome to employers. Only if introduced when short time is being worked can the change be accommodated without an effective rise in wages. But it is as natural that unions should wish to see a shorter working week introduced before business becomes this slack (with the possibility of redundancy developing) as that employers should wish to avoid reducing hours of work if it will add anything to production costs. Mr. Carron is right. The forty-hour week will certainly come. But whether this is the right moment for its introduction is quite another matter.

THE "JUNIORS"

We are frequently invited to Institution dinners and luncheons, and never do we minimise the importance of such functions. Many of them are distinctly formal occasions, with weighty utterances included in the post-prandial speeches ; some of them strike a lighter note of informality, with speeches that are designed to end before anyone present can possibly tire of listening to them ! In this latter category, we place without hesitation the seventy-fourth annual dinner of the Junior Institution of Engineers which we had the pleasure of attending last Friday evening. The Junior Institution is an energetic body, membership of which is "open to men of all ages engaged in any branch of the engineering and allied professions, wherever resident." Since 1884, it has existed "to promote the science and practice of engineering and the consideration of all questions affecting engineers."

The informal atmosphere which characterises the Junior Institution's meetings, in London and the provinces, was fully maintained at its dinner last Friday. At first sight, the toast list looked formidable, for it indicated no less than eight speeches. But we hasten to add that they were eight excellent speeches, all of them models of brevity and commonsense. It was, for example, beneficial to be reminded by one of the guests, the president of the Institution of Highway Engineers, that it is an exceedingly good thing for engineers to relax occasionally from their customary labours ! It was equally beneficial to listen to the speech of another guest, a senior vice-president of the Institution of Electrical Engineers, who stressed the importance, to younger engineers especially, of being able to obtain some knowledge of those fields of endeavour which are outside their own particular speciality. To that desirable end, the Junior Institution continues to apply itself by providing opportunity for the full and free discussion of distinctly practical papers. As was fittingly remarked during the evening by the Institution's chairman "men of high standing have been proud to call themselves Juniors." Some of them may now have passed the traditional allotted span of three score years and ten ; they nevertheless share with the Institution's membership as a whole a vigorous and "matey" approach to the progress and problems of the day. That, surely, is a virtue worthy to be preserved. Long may the "Juniors" flourish.

The Engineer — 100 Years Ago (APRIL 30, 1858)

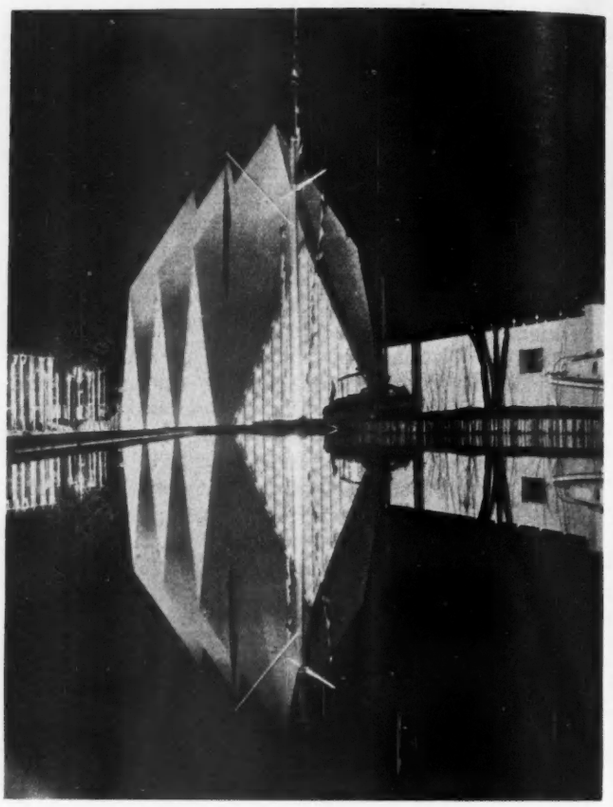
"THE SMOKE NUISANCE"

"Two associations connected with this subject have recently come into existence—one for the purpose of affording protection to 'smokers' who get into trouble in consequence of not conforming with the regulations laid down by the Act of Parliament—the other, upon an entirely opposite principle, offers its assistance in the endeavour to comply with those regulations, and thus to save the trouble either of prosecution on the one side, or of defence and justification on the other. The latter association, under the title of the London Smoke Prevention Company (Limited), sets forth as its object, the prevention of smoke from the furnaces of fixed, locomotive and marine, boilers, factories, and domestic stoves. In their prospectus they put forward the opinion that 'the dense atmosphere over London and other large cities is owing more to the aggregate nuisance arising from the chimneys of private houses and dwellings than to the dense volumes which are seen to issue from factories.' That this is the case we believe there is little reason to doubt. The too familiar 'blacks' with which one is inundated on attempting to admit fresh air by opening a window certainly originate chiefly from this source. . . .

"The method by which the company propose to prevent smoke in boiler and other furnaces consists, essentially, in the application of a current of heated air for the combustion of those gases which would otherwise produce smoke. For this purpose air is introduced through the upper part of the furnace door and at the bridge ; a casing is attached to the furnace door, which serves to heat the air in its passage through this casing to the flame arising from the coal. . . . The London Smoke Prevention Company proceed upon the belief that the use of hot air is preferable to the use of cold air, because it does not lessen the steam-generating capacity of the boiler. . . ."

INTERNATIONAL & UNIVERSAL EXHIBITION —BRUSSELS 1958

No. III—(*Continued from page* 612, *April* 25)



DURING the last century, thirty World Exhibitions have been held, beginning with the Great Exhibition in London in 1851. Thirty-four years later came Belgium's turn with Exhibitions in Antwerp (1885, 1894 and 1930), Liège (1905 and 1930), Ghent (1913) and Brussels (1888, 1897, 1910 and 1935). The last fair to be held was the New York World Exhibition of 1939. After an interval of 19 years, the 31st International and Universal Exhibition opened in Brussels on April 17, and will remain open to visitors from all over the world until October 19. Sited on an area of 200 hectares—one-third the size of Brussels and 1½ times that of Hyde Park—the Exhibition is an event which according to the 1928 Agreement cannot be repeated in Europe for at least six years. Our article describes the fair, in which Great Britain is taking a prominent part. The general theme is "A Balance Sheet for a More Human World," and besides the Belgian and Foreign Sections, there is for the first time an International Section representing the important international bodies which have come so much to the fore in recent years. The accompanying illustration shows the British Government Pavilion after dark: it is reflected in a lake that is also part of this country's exhibit, and on which there float small marine craft.

Nuclear Power and the British Industry Pavilion.

THE peaceful uses of atomic energy are prominently represented in the British Industry Pavilion, the International Pavilion and the International Hall of Science. Both the Atomic Energy Authority and industrial firms are participating in the British Industry Pavilion.

In the exhibit arranged by the Board of Trade the Atomic Energy Authority seeks, through the medium of models and photographs, to develop a simple but connected theme based on the expanding needs for energy throughout the world, the growing dearth of fossil fuel and the increasing importance of the new fuels, such as uranium and thorium.

The first large-scale development illustrating the use of uranium for developing nuclear power is at Calder Hall, which began operating on October 17, 1956, and had generated more than 560 million units by the opening day of the Brussels exhibition. A log sheet brought up to date daily shows visitors the exact number of units generated at Calder Hall.

The exhibit shows that four more nuclear power stations evolved from Calder Hall, but with much larger outputs ranging from 300MW to 500MW, are now being built for electricity supply authorities in Great Britain. In stations of this kind 1 ton of uranium does the work of 10,000 tons of coal, but has an even higher potential, and research work is in hand to obtain greater outputs from each ton of uranium. For example, in reactors such as "NERO" at Harwell the U.K. Atomic Energy Authority is seeking ways of recycling uranium and, by loop experiments, is studying means of raising the temperature at which fuel elements can operate. The value of research is shown by the fact that for a power programme of 6000MW roughly 10,000 tons of uranium fuel would be needed every four years with the present kind of reactor. By recycling plutonium the demand could be reduced to 2000 tons every four years for the same amount of power, but with advanced reactors the possibility arises of cutting this fuel requirement to only 100 tons every four years, and at the same time increasing the power. To gain such a reward one must develop breeder reactors such as the fast breeder reactor at Dounreay, of which a very large model is on view at Brussels, the sphere being 17ft in diameter. Another exhibit is an animated diagram of an experimental homogeneous aqueous reactor. Both these reactors are intended to be used with thorium as a breeding material. In the homogeneous aqueous reactor the fuel is dispersed in the heavy water coolant/moderator and is surrounded by a thorium blanket. The main problems to be solved in such a system are those associated with corrosion under high temperature and radiation conditions and with the need for providing a leak-proof system to contain the highly reactive solutions. The Authority is also showing, for the first time, a model of the high temperature gas-cooled reactor which is being built at Winfrith Heath in Dorset.

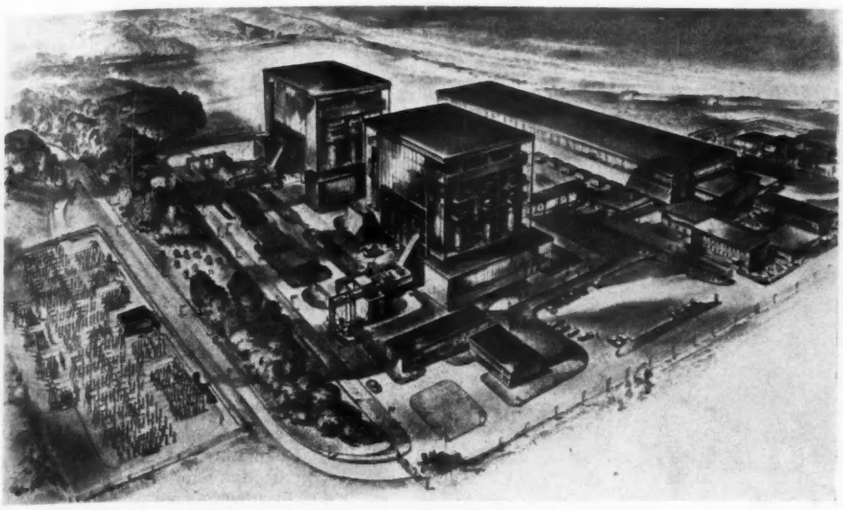
Finally, the Atomic Energy Authority's exhibit illustrates the possibilities of power from nuclear fusion and shows the way in which Great Britain has taken the first step towards a controlled thermo-nuclear reaction with "ZETA."* In this exhibit "ZETA" is represented by a large colour transparency.

But in the British Government Pavilion there is a one-third scale model, 7ft high, of "ZETA," built for the Central Office of Information by Miniature Engineering Ltd. In the torus of "ZETA" temperatures of 5,000,000 deg. Cent. have been attained in experiments which have led to the conclusion that the control of fusion and the use of the waters of the oceans as fuel for power may well be a possibility for the future. The torus is made of "Perspex" so that the interior flash (simulating the pinched discharge in "ZETA" itself) can be seen at ten-second intervals. It is mounted on a platform and so sited that it forms a natural climax to a series of scientific exhibits. Flanking it will be a display of thirty-five British Nobel prize winners in science. There is also a simple direct message that "on the night of August 30, 1957, a great step towards a new source of power for mankind was taken. On that date scientists at Harwell succeeded in attaining temperatures of five million degrees centigrade and released neutrons in the thermonuclear reactor known as 'ZETA.'"

* The Engineer, January 31, 1958, page 160.

British Industry's Contribution to Nuclear Power Generation

The 500MW nuclear power station under construction at Hinkley Point, Somerset, provides the theme of the exhibit shown by the English Electric–Babcock and Wilcox-Taylor Woodrow Atomic Power Group, the consortium which is building this power station on behalf of the Central Electricity Generating Board. The design of the station was outlined in our issue of September 20, 1957, page 415, and March 14, 1958, page 402. Briefly, the plant will consist of two gas-



An artist's impression of the 500MW Hinkley Point nuclear power station as it will appear when completed in 1962

cooled, graphite moderated reactors, each contained in a spherical pressure vessel 67ft (20·4m) in diameter and made of steel 3in (76·2mm) thick, the weight of each reactor with its pressure vessel being 5500 tons. The fuel will consist of natural uranium in magnesium alloy " cans " and refuelling will take place from the top of the reactor while it is pressurised and on full power. Steam will be generated in Babcock dual-pressure heat exchangers of which there will be six per reactor. Each heat exchanger will be 90ft (27·4m) high and 21ft 6in (6·6m) in diameter and will weigh 1350 tons. The total evaporation will be 5,500,000 lb (2,500,000 kg) of steam per hour. Gas circulation between each reactor and the associated heat exchangers will be effected by six electrically-driven axial-flow circulators. Electricity will be generated in the turbine hall (on the right of the accompanying illustration) by six English Electric hydrogen-cooled three-cylinder turbo-alternators, each with a rating of 93MW at 13·8kV, 0·85 power factor. Supplies to the gas circulators and other auxiliaries will be provided by three 33MW variable speed turbo-alternators. The main output will be fed into the 275kV national grid system through a switching and transformer station which is illustrated on the left of the picture.

The civil engineering work will include the construction of two reactor buildings each 180ft (54·9m) high, the reactor shielding which is of high density concrete 7ft (2·13m) thick, a turbine hall 740ft (225·6m) long and other smaller buildings, a sea wall 3000ft (914m) long and a circulating water intake structure.

Other major items of civil engineering work will include a tunnel 2200ft (670m) long under the sea bed and a dock, wharves and approach roads. All these works will involve 750,000 cubic yards (573·75 cubic metres) of excavation and the placing of 300,000 cubic yards (229·5 cubic metres) of concrete.

The contract for the building of the power station was placed in September, 1957, and completion is expected in 1962. Considerable progress has already been made. In three months nearly 175,000 cubic yards of rock and earth were moved and by mid-April work was completed on the concrete foundations of the first reactor. Construction of the biological shield (90ft high and 75ft in diameter) was started in April, progress is being made on the foundations for the circulator houses and steam raising units and excavation has begun over the area to be occupied by the turbine house.

Another major development is taking place on the sea front where the 3000ft long mass-concrete sea wall is to be built, incorporating the pump-house for the circulating water system. Cooling will require 35,000,000 gallons of sea-water per hour which will enter the pump-house through two 11ft diameter tunnels from an intake structure 2200ft offshore. The first stage in this work was the reduction of the sea front area to a general level of 36ft above sea level, the excavated material being used to reclaim parts of the foreshore which formed part of the land over 100 years ago. The reclaimed area will be up to 250ft wide and 3000ft long and will house some of the site buildings. Preliminary investigation on requirements of the work on the cooling water system, for which the use of divers was necessary, began some time ago and constructional work began in April.

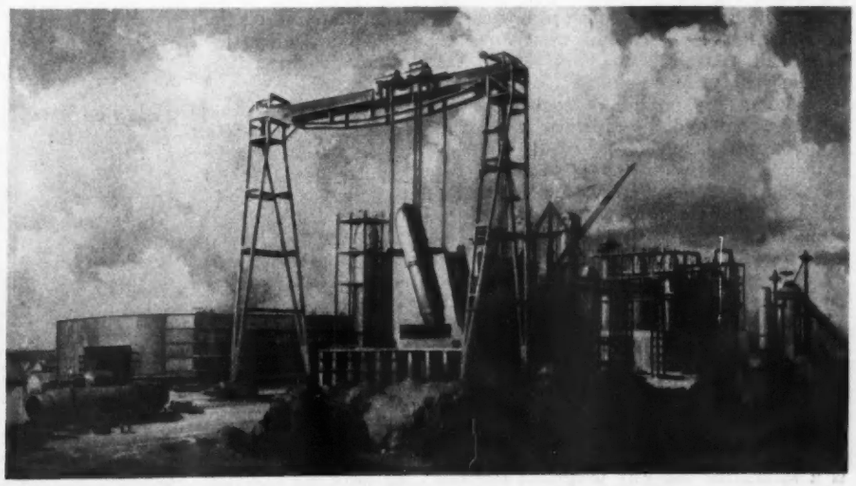
Extensive workshop facilities have now been built on site ready for occupation by teams of fitters, welders and plant erectors. The present labour force totals 1200, about 400 of whom are now housed in a small township which has grown up near the site.

The exhibition stand which is mainly devoted to the Hinkley Point scheme is an unusual structure consisting of a central office suspended above the floor from an arched roof of copper-anodised aluminium. Below this office structure the main exhibit is an animated sectional model on a base 3ft square of one of the Hinkley Point reactor buildings in which the flow of coolant gas through the reactor and of steam to the turbines is represented by coloured light tubes.

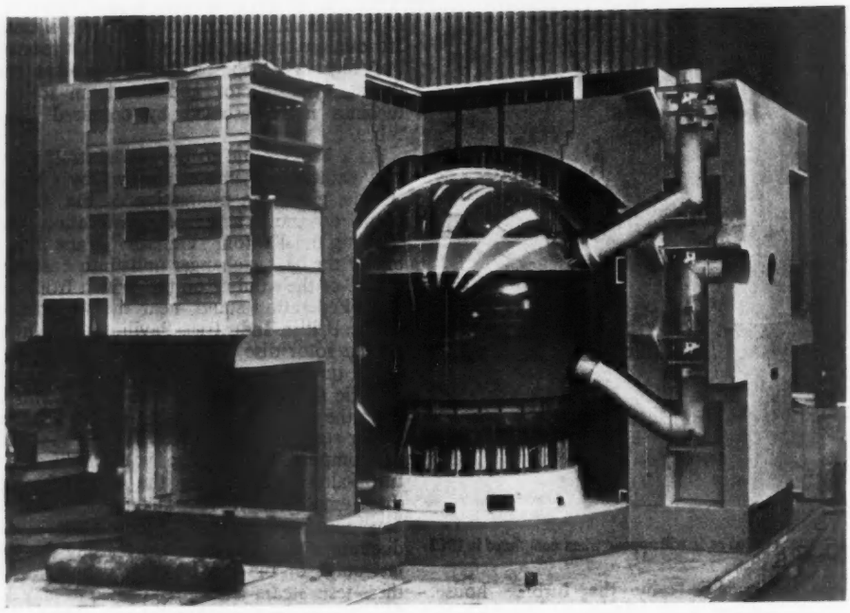
As a background to the model itself there is a painting (illustrated below) by Claude Buckle, giving an impression of the station in an advanced stage of construction and showing the 400-ton " Goliath " crane lifting one of the heat exchanger units into position.

One of the exhibits on the British Iron and Steel Federation stand, near the sub-station in the British Industries Pavilion, is a fully-bladed rotor disc for a 200MW 3000 r.p.m. steam turbine, manufactured by the English Electric Company, Ltd. The disc shown is from the prototype wheel for High Marnham power station on the River Trent, for which the company is supplying five 200MW steam turbo-alternators. It is the actual bladed disc employed in the experimental and development work that preceded the introduction of the 27in reaction blading for the last stage of the low-pressure exhaust. In these tests steam jets were adjusted to play on the blading with varying intensity, direction and point of application. In this way it was demonstrated that the blading, which has an active length of 27in and is stiffened by three rows of lacing wire or tube, gave only a weak response to heavy exciting forces during the tests. In the turbine itself, of course, care is taken to ensure that the steam flow from the stationary nozzles is uniform, so that no significant vibration of the blades can occur. After being on exhibition for six months at Brussels, this disc will go into the permanent exhibition of the metallurgical section of the Science Museum in London.

Power and lighting supplies to the British Industries Pavilion and the British Government Pavilion at the Brussels International Exhibition are controlled by two sub-stations. Like the British Industries Pavilion itself, the No. 1 sub-station at the north end of the Pavilion is virtually glass walled and visitors to the Fair can see the English Electric sub-station which controls electrical supplies while serving as a working exhibit. This substation, which has been installed by the electrical contractors, James Kilpatrick and Son, Ltd., of London, has a capacity of 1000 kVA and takes its supply from a ring main installed by the Société de l'Exposition through a six-panel type O.L.X. high-voltage switchboard. Two 500kVA 11,000/415V, 50 c/s oil-cooled transformers feed on to a



Reproduction of a painting by Claude Buckle giving an impression of an advanced stage in the construction of the 500MW Hinkley Point nuclear power station



Sectional model of reactor building for a 400MW graphite-moderated, gas-cooled nuclear power station

" Superform " medium-voltage switchboard comprising two 800A. " OB.23 " air circuit breakers and twenty-two outgoing H.R.C. fuse switches.

The whole of the stand taken by the Nuclear Power Plant Company, Ltd., Booths Hall, Knutsford, Cheshire, is occupied by an impressive scale model of a nuclear power station incorporating two graphite-moderated gas-cooled reactors fuelled with natural uranium. The model represents a station of the type now being built in Great Britain, but having an electrical output of 400MW.

As illustrated here, one of the reactor buildings is sectioned to show a spherical pressure vessel, two of the six boilers and the layout of the gas ducting. Charging and discharging of the fuel elements (magnesium alloy sheathed) in the cylindrical graphite core is effected by a machine on the floor above.

In this model operation of the reactor is simulated by movement of the control rods. When it is active the core is illuminated red and the colour changes to green during shutdown. One of the boilers is sectioned to show a representation of the internal tubing which contains coloured bubbles to indicate the change of water into steam.

Another model, in front of the model of the reactor building, depicts a fully equipped turbine house, with four main turbo-generator sets and their control panels in the main hall and three auxiliary sets in the smaller hall to supply power for the gas circulators. The station control room, battery room and diesel engine room are also shown in model, as is the outdoor switching station on the far side of the turbine house. On the opposite side of the stand, beyond the reactor building there is a model of an enclosed pond in which spent fuel, after removal from the cores by remote handling plant, is stored for about three months to allow the radioactivity to decay. Then they are taken to a separate reprocessing plant for extraction of plutonium.

Other British Industrial Exhibits

Prominent among the exhibits shown by Standard Telephones and Cables, Ltd., Connaught House, Aldwych, London, W.C.2, is a submarine two-way telephone repeater of the kind installed in the new Anglo-Belgian submarine cable system. This important submarine telephone link was provided by S.T.C. and its Belgian associates the Bell Telephone Manufacturing Company, Antwerp. These two companies were jointly responsible for the manufacture of the cable and the submerged repeaters and for the supply and installation of the land-based terminal equipment and cable.

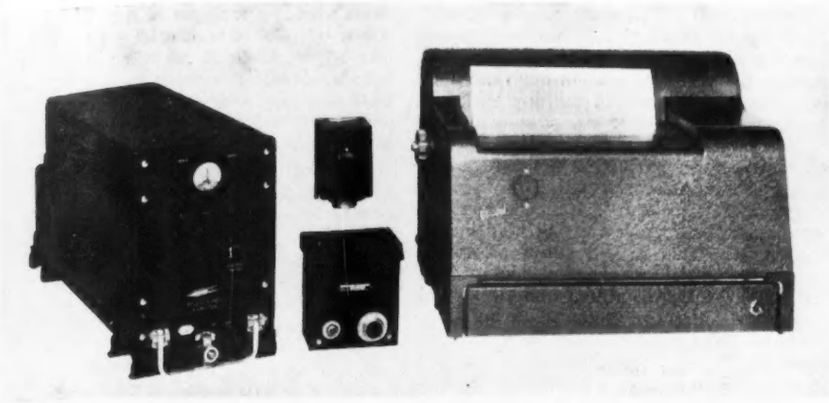
The system provides 120 two-way telephone channels having a performance meeting C.C.I.T.T. recommendations, over a single submarine cable using a frequency band of 60–552 kc/s in one direction and 672–1164 kc/s in the other (i.e. two supergroups of coaxial system). At the British end of the link, the " submarine " terminal is at the British Post Office Repeater Station at Canterbury, where it is connected with the national telephone network via the existing 2·6 Mc/s coaxial cable telephone system supplied and installed for the British Post Office by Standard Telephones and Cables, Ltd. Cable terminating equipment and additional carrier telephone equipment to cater for the new circuits are provided at Canterbury. This equipment works into a cable approximately 16 miles (26km) long, similar in general construction to the submarine cable, connecting Canterbury with Dumpton Gap on the Kent coast where the actual submarine cable terminates.

The undersea cable itself has a sea length of approximately 55 nautical miles (102km) and consists of a polythene-insulated coaxial cable containing an inner copper conductor made up of a strand of seven wires insulated from the outer conductor by a solid dielectric of polythene. The outer conductor consists of a layer of six copper tapes plus one copper binding tape. Overall the cable has a serving of tarred jute and a final armour of galvanised steel wires. The land cable sections have a double sheathing instead of the jute and steel wires. The inner sheath consists of pure lead and the outer of black polythene. The submarine cable was made at the new Southampton factory of Standard Telephones and Cables, Ltd., where special facilities exist for the manufacture and testing of such cables. The land cable was made at the company's North Woolwich works. Laying of the sea cable was carried out by the British Post Office.

Three rigid two-way submerged repeaters are spliced into the cable at predetermined intervals. They are similar in construction to those supplied by S.T.C. and now in daily use on the Newfoundland–Novia Scotia section of the Transatlantic Telephone Cable scheme, and between the Netherlands and Denmark. Each repeater is housed in a steel tube approximately 9ft (274cm) long and 10½in (27cm) diameter and is laid on the sea-bed as an integral part of the cable. When the repeater is spliced into the submarine cable, the armour wires of the cable are clamped to robust anchor plates, to ensure that no stress is transferred to the cores of the cable where they enter the special glands fitted at both ends of the repeater for the necessary circuit connections. The amplifier unit of the repeater serves both directions of transmission and consists of two amplifiers connected in parallel between common input and output transformers and with a single feedback network. This circuit arrangement ensures that if one amplifier path fails the gain of the complete amplifier is not appreciably affected. The submerged repeaters are energised by a constant-current d.c. supply fed between the centre conductor of the cable and earth. Power for the purpose is provided by specially designed power plant which has been supplied and installed by the contractors at the Canterbury and Ostend Repeater Stations.

The submarine cable crosses the Belgian coast at Middelkerke and from thence a length of some 5 miles (8km) of land cable similar in construction to the Canterbury-Dumpton Gap cable connects it into the Belgian " submarine " terminal located at the Ostend Repeater Station. Here, as at Canterbury, cable terminating equipment and carrier telephone equipment for the new circuits has been provided. From Ostend to Brussels the link continues as two 60-circuit systems over symmetrical pair cables provided and installed under the ægis of the

" Stantec Zebra " computer



Airborne teleprinter equipment first used on a scheduled flight of a BOAC "Stratocruiser"

Bell Telephone Manufacturing Company, who also supplied and installed suitable terminating equipment so that the 120 circuits made available by the submarine cable system may be fully integrated with the national and international telephone networks.

Another exhibit, the "Stantec Zebra"—a medium-size general purpose digital computer applicable to both scientific and commercial work—can be seen in operation. "Stantec Zebra" is a serial binary computer with a word length of thirty-three bits. It consists of four units (illustrated on page 646). First the arithmetic unit which has two accumulators each equipped with an adder/subtractor and shifting and clearing facilities. Secondly, the immediate access registers. There are thirty-two registers of which twelve are one-word immediate access stores having reading and writing facilities. Others store useful constants such as zero, -1, 2^{-32} &c., and yet others are associated with the input and output channels. Thirdly, the main store which is a magnetic drum of eight 192-word capacity having 256 tracks each containing thirty-two words. It rotates at 6000 r.p.m., i.e. 10 milliseconds per revolution. The word time is thus 312 micro-seconds.

Fourthly, the control unit which staticises the instruction being executed during any given word time and, together with that instruction, determines the interconnections between the four basic parts of the computer and the form of the arithmetical operations. It also selects the next instruction to be carried out.

The form of the instruction is distinctive to "Stantec-Zebra." In each instruction there are fifteen "function digits." Each of these function digits, which are not decoded, controls one specific operation within the machine.

Since any or all of these digits may be used in any one instruction, the user may construct a possible 2^{15} different instructions. A further five digits specify which one of the thirty-two immediate access registers is to be used and the remaining thirteen digits of the instruction specify one of the eight 192 main store locations. Both of these "addresses" may be used in one instruction. Every instruction is executed in one word time.

But because any instruction may contain several function digits a number of operations occur simultaneously. For example a single instruction may transfer the contents of an accumulator to a specified location, clear the accumulator, add in the contents of an immediate access register, count in the other accumulator, and specify the source of the next instruction—all in one word time.

Multiplication, division and other mathematical operations are carried out by short sub-routines in a programme, and some sample operation times are: Addition or subtraction, 312 micro-seconds; multiplication, 11 milliseconds; division, 35 milliseconds; square root, 80 milliseconds; floating decimal operation, 30 milliseconds (average). When, however, these figures are considered as criteria of performance, account must be taken of the fact that the logic permits several functions to occur simultaneously. The result is that the overall operational time for specific problems compares favourably with other machines of apparently greater speed.

For those users who stress ease of programming even at the expense of some loss of speed, a simple code has been devised. This code consists of one function letter and one address for each instruction and is used in conjunction with an interpretative programme stored within the machine. When using this code all numbers are represented in the floating decimal form. Although the speed is about one-fifth that of the normal code speed, using fixed point binary notation, this is very favourable for full floating point operation, on a comparative basis.

A new exhibit is a working demonstration of a lightweight teleprinter and radio receiver designed to provide meteorological and navigational reports to pilots of aircraft in flight. Equipment of this kind installed in a British Overseas Airways Corporation Stratocruiser, on a scheduled flight from London to New York, has recently successfully recorded meteorological and navigational reports transmitted by radio stations in Britain and Newfoundland. This was the first time in the world that information destined for the pilot of an aircraft in flight was successfully communicated by means of a radio teleprinter circuit.

The airborne installation (the components of which are illustrated here) consists of a special receiver and teleprinter. The "SR.24" four-channel M.F. airborne radio teleprinter receiver has a frequency range of 95–140 kc/s. Its sensitivity is defined as: faultless printing for input signals (±20 c/s deviation) of 20 dB below 1μV into 75 ohm input terminal of the receiver. The airborne teleprinter was specially developed for airborne use by Creed and Co., Ltd., an associated company of S.T.C. The teleprinter is capable of operating at 100 words per minute. The weight is approximately 35 lb.

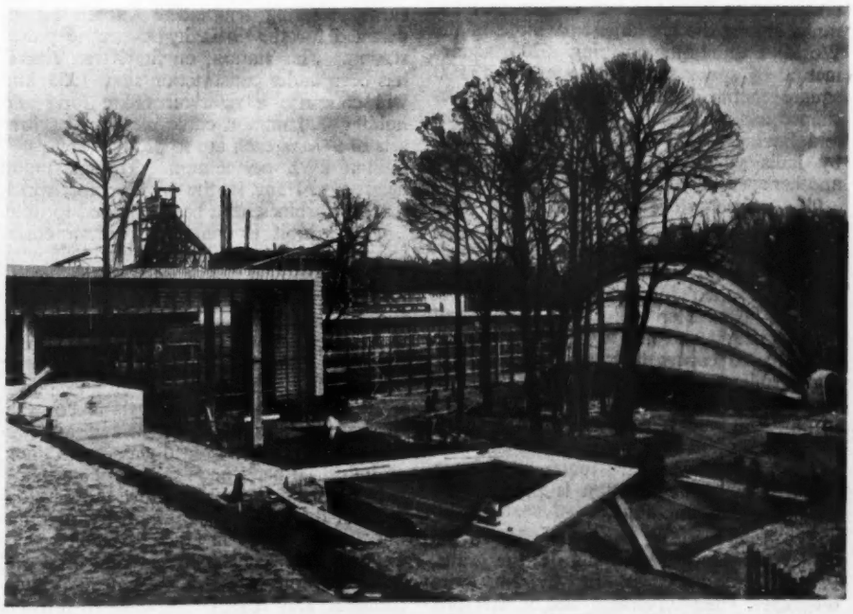
This equipment displayed at Brussels is receiving signals over direct radio transmission from a British Ministry of Civil Aviation transmitter installed at Prestwick in Scotland, a distance of approximately 500 miles (800km).

In the remainder of this article we shall deal with a few of the most important other foreign pavilions, and with the International Sections.

The Netherlands

The area set apart for the Netherlands display covers 6¼ acres; this shares with France, the United States and Soviet Russia the distinction of being the most extensive area made available for foreign participants.

"The water as friend and foe" has been chosen as the theme of the Netherlands contribution, and, in fact, the sloping ground of the Netherlands terrain at the World Fair offers excellent opportunity for attractive



The Netherlands pavilion under construction, showing a view from the top of the dyke into the polder. The domed building houses the exhibition dealing with the Zuider Zee reclamation and the Delta plan

application of such a theme. The scheme of the Netherlands Section includes collective contributions by industry, trade and transport, as well as exhibits in the fields of art and science, social welfare and religion. The exhibition terrain is, as it were, divided into two parts (page 647). The lower part reveals the polder landscape and shows the Netherlands as an agrarian country ; the upper level gives an impression of the industrial development of the Netherlands, and that essential element of a polder, the dyke, is used to separate the agricultural and industrial sectors.

But the dyke is by no means the only echo of the typical polder landscape, For through the reclaimed land in this "miniature Holland" there run the canals from which the water is pumped over the dyke into a water basin, which, in its turn, serves the industrial sector for demonstrations in shipping, coastal lighting and other maritime activities.

Then, too, the polder is the natural place in which to show visitors how land reclamation is conducted in the Netherlands. Under a dome-shaped roof models illustrate one of Holland's large hydraulic works, the reclaiming of the Zuyder Zee, and the mammoth Delta Plan by which the large sea arms on the south-west coast will be closed, as well as many scientific experiments, studies and methods which are indispensable for the execution of such engineering works.

Agriculture claims the remainder of this sector on one side, and flanking the upper level water basin on two sides are exhibition halls, one of which stretches down into the polder area.

These pavilions house the collective contributions of the various industries, including trade and transport. Here, too, is shown a cross section of the culture and art of the Netherlands, of the spiritual life of its people and of the social development of the country, as well as exhibits showing the overseas territories. As befits a land in which flowers play so prominent a role, the pavilions are lavishly decorated with floral and plant displays.

Czechoslovakia

The Czechoslovak pavilion, which we illustrated on Plate 6 in our issue of April 25, ranks among the ten largest pavilions of the World Exhibition, covering 6200 square metres of space set in an area of 13,000 square metres. It comprises three cube-shaped exhibition halls, with 18m long sides and having solid external walls, connected by halls which are glazed. Opposite is another smaller building housing a restaurant.

The Czechoslovak pavilion can be readily dismantled, being a partially prefabricated steel structure assembled by welding and bolting. The skeleton is made of standard rolled joists and seamless steel tubing. The latter was chosen because of its low weight and fine appearance. In the cube-shaped corner halls a system of four corner pillars, without intervening supports, was chosen, as it allowed full use to be made of all internal space. The roofs were made as flat as the construction allowed, to meet architectural requirements. A broad area of illumination is provided by transparent roofing units.

The need for easy dismantling led to the choice of panels for filling in the walls. Panels of foam glass, 1m by 2m, were selected. Their advantage lies in the fact that they have high insulation values and are light in weight. The façades have been decorated with gilt mosaics, producing contrasts by the effect of light on large areas. The internal arrangement of the pavilion permits the visitor to pass through the halls in an unbroken path in keeping with the sequence of displays.

Although the industrial section of the Czechoslovakian pavilion is not particularly large, it contains representative examples of the machine tools and instruments made in the country and an interesting model of a coal mine. This model, about 5ft to 6ft square, is made in transparent plastics to show the buildings above ground and the actual mine workings. The ground level buildings show the extensive amenities block with its baths and changing rooms, and at intervals the model is slowly raised to show the underground workings at successive levels. In the various working areas and roadways, there are models of the machines and equipment in use and they give an excellent impression of working conditions as well as mine working layout. At the side of the model is situated the pithead gear and main cage system used for coal winding purposes.

The centre piece of the machine tool exhibits is a large boring machine with pendant control, and two of the interesting machines under power are a copying lathe and an internal grinding machine. This copying lathe for shafts up to 9¾in diameter and 39in long is fitted with means of automatic programme control by the setting of pins in a co-ordinate selector in accordance with holes in a master setting card, or it can be used with normal template or master workpiece hydraulic tracer control. It has twelve spindle speeds from 71 to 1800 r.p.m., and, like the feeds, they can be changed automatically whilst the machine is running to ensure economical cutting in accordance with diameter changes. Two tool slides, with copying control are provided one above and one below the work, and these slides can be used individually or together as required. The internal grinder is also arranged for automatic cycle operation and is designed to take work from 80mm to 500mm diameter. Automatic gauging during the grinding operation sparks out the wheel on size being attained, and an accuracy of within 0·0003mm is claimed for the machine.

Adjoining the main building is a tubular tower structure from which is suspended a slowly rotating ten-bladed Kaplan runner destined for the Orlik hydro-electric power station. This station, on the River Vltava, has been under construction since 1955, and will comprise a reservoir 68km long and holding 720 million cubic metres. Its four sets of 94MW each are to produce some 400 million kWh per annum. The maximum head of 70·5m is the highest for which Kaplan turbines have been supplied to date.

This exhibit is connected with a corresponding section inside the pavilion showing the development of Czechoslovak water power since 1946, in which period thirty large dams have increased the country's storage capacity to six times its value pre-war. The display also shows models of an atomic reactor and an atomic power plant, together with illustrations covering the rich uranium mines. Behind a heavy shield of concrete and lead glass 1·5m thick, an industrial betatron is seen in operation.

Documentary displays show the development of the iron and steel industry, amounting to an increase in annual capacity, since 1949, of over 1,500,000 tons of pig iron and 1,300,000 tons of steel. Eight new blast-furnaces and fifteen open-hearth furnaces have been put into operation during this period. Czechoslovakia claims to be the world's leading producer of sugar beet, a fact which is reflected industrially, for there are 500 sugar refineries in the world which Czechoslovakia has either built or equipped. In the past five years alone, the country has supplied over 300 different industrial installations abroad.

The Industrial Section is completed by an extensive array of the products of the ceramics, glass and textile, and other light industries. Other principal sections cover agriculture, forestry, leisure and culture.

The exhibits have been selected and grouped carefully for balance and beauty of presentation.

German Federal Republic

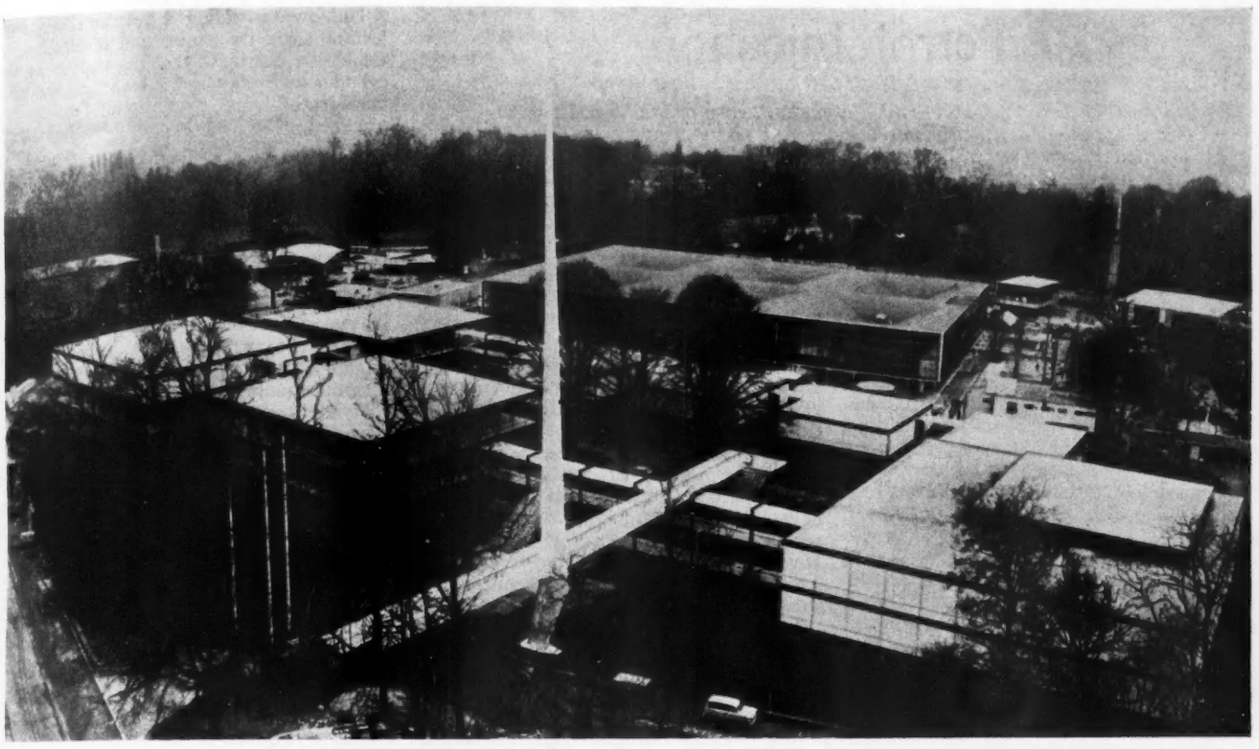
The German exhibition is in the southern part of the Foreign Section, and (as illustrated opposite) adjoins the British pavilions. It is on an area of 18,000 square metres in the wooded park of Laeken, on a slight slope. There are eight pavilions, all of square plan, but of three different sizes and having either two or three floors. Sited in an approximately rectangular arrangement, the pavilions are connected by a footbridge at second floor level ; this bridge is accessible from the hillside over a 57m long unsymmetrical suspension bridge supported by three pairs of cables from a single 52m high pylon. All the buildings are steel-framed and were prefabricated in Germany. The outer walls are of glass, and in each room a 50cm wide strip below the ceiling was left unglazed in order to achieve natural ventilation. Altogether, the roofed-over area amounts to 6000 square metres, and the stand area totals 5000 square metres.

The exhibition itself is based on the general theme, interpreted as implying that the scientific and technical achievements of our time only fulfil their purpose if they help to give to humanity as a whole and to every individual an adequate living standard and full possibilities of development. All exhibits therefore refer as directly as possible to man in his daily existence, and no item is shown for its own sake. The participation is divided into agriculture, crafts, industry, towns and housing, personal requirements, social tasks, leisure, sickness and health, and education and training.

In the agricultural show are illustrated the improvement of working conditions and increase of productivity in the countryside, mechanisation, new means and methods of feeding and manuring, land redistribution in order to rationalise the holdings, improvements in organisation, modern farmsteads, and the efforts to overcome the drift into the towns. These topics are illustrated by photographs and drawings, and by a presentation of old and new agricultural machinery.

The theme of the crafts exhibition is the permanent importance of the crafts for all work requiring an individual approach. The effect of the introduction of new materials and new tools is illustrated, as is the influence of craftsmanship upon industrial production.

Following the preceding section is the exhibition devoted to industry. Here, the change-over from manual to machine production is illustrated, and it is shown how the increasing world population and the gradual exhaustion of many materials make it necessary, on the one hand, to increase production of all kinds of goods, and, on the other hand, to widen the raw materials basis by the introduction of many man-made substances, such as plastics. This development led to a shift in the quality of the work,



The group of eight pavilions in the foreground forms the German exhibition. Access to the connecting foot-bridge is over the asymmetrical single pylon suspension bridge. Behind can be seen the British Industry Pavilion

from manual to mental effort. A final section deals with the importance of good design.

One complete three-storey section of the German group of buildings—Pavilion No. 2—is devoted to industrial exhibits mainly concerned with the manufacture of iron and steel and the processing industries. Some excellent models—many in transparent plastic materials—are used to show the details of large plants, and processes are explained by means of large flow diagrams.

The models include one of a Renn plant for the reduction and sintering of low-grade iron ore; it is similar to the plants installed in Essen, and one now under construction to serve a group of companies in Germany. It is stated that when this second plant is in operation it will reduce by half the present scrap requirements of the firms. This model is followed by one of a blast-furnace and the sequence completed by a model of a modern continuous strip mill. Typical rolling mill stands and rolls are shown, together with the stand of a broad flange rolling mill, with a piece of the new I.P.E. standard section in it. Another transparent plastics model shows the arrangement of the recently developed Graef rotary oxygen steel-making equipment, one of which is now under construction at a German plant. Complementary to some examples of heavy forgings which are shown is a large scale model of a hydraulic forging press with hydraulically operated manipulating equipment.

Other large exhibits include two heavy forgings for nuclear reactors and the domed end section of a large lined pressure vessel. A large exhibit of interest is a high-pressure strip-wound vessel for high-pressure synthesis. This vessel consists of a thin section core tube wound on the outside with layers of thin metal strip and this form of construction is stated to provide an economical means of building a vessel which will contain pressures of up to 5000 atmospheres.

The development which has taken place in internal combustion engine design is shown graphically by a modern twelve-cylinder, 250 h.p. Deutz engine by the side of the first Otto atmospheric gas engine—which was exhibited at the Paris World Exhibition in 1867, where it was awarded a gold medal. An interesting demonstration of the shell moulding process is given at intervals in a compact foundry installed in a section of the ground floor of the building. A model of an apprentice workshop is used to show modern training methods and give some indication of the skilled labour requirements for industrial expansion. Other exhibits of interest include precision optical equipment and chemical processing plant, with examples of some of the products.

The group of iron and steel companies known as Wirtschafts Vereinigung Eisen-und Stahlindustrie, Düsseldorf, has a small exhibition and an information bureau in one of the spheres of the Atomium. In addition to models and representative examples of the products of some of these firms, this smaller exhibition contains a wall diagram on which the firms' names are grouped in their various localities. By pressing a button by a firm's name on a small control panel, its name is illuminated on the diagram, with adjoining coloured lights, showing its particular class of work, i.e. blast-furnace plants, steel works, rolling mills, tube mills, plants making alloy and special steels, press shops and forges, factories for wheel sets and refining plant.

Yet another pavilion deals with the problems of living in towns, and the recent German developments in town planning, with special reference to municipal blocks of flats. This exhibition which also covers the interior fixtures, furniture and equipment, is particularly well-illustrated by models and pictorial representations. There are two full-size flats to be seen, one of 100 square metres for a family, as an example of municipal building, and one of 30 square metres for a single person. Examples of furnishing fabrics, wall papers, household equipment and individually-made furniture, are arranged in a demonstration showing part of a dining room.

In the section devoted to consumer goods is shown the contrast between the time, a few decades ago, when articles such as clothing, personal equipment and luxury goods, predominantly were in the high price category, whereas nowadays there is a large number of such products available at reasonable prices.

Social insurance and care is shown in another pavilion which exhibits the measures taken by the community to provide pension funds, sickness benefits, accident and unemployment insurance, and care for mothers and children, young people, the sick, old, persons in need, victims of the war and of accidents, and refugees.

Technical progress shortens the working time and gives people more leisure. In another section of the exhibition it is shown how science and technology help people to realise their wishes and aspirations for their hours of leisure. Here may be seen in old pictures and engravings the old dreams of mankind, and by means of modern instruments and equipment how they have been realised in modern times by the telescope and microscope, photographic camera and tape recorder, wireless and aeroplane. Pictorial illustrations show the various ways in which people spend their leisure.

In the next pavilion, which has the theme "To prevent is better than to cure," are shown the various factors which contribute to illness and to health. Personal hygiene, healthy food, medical care, recreation and rehabilitation are the subjects which are illustrated.

Education and development of the personality, from the young child to the adult, is the theme of the final pavilion, which shows the dangers to freedom and spontaniety which frequently arise in an industrial society, and how these dangers can be overcome. "Progress exists ultimately only where people progress in their humanity."

(*To be continued*)

Petrol Injection

No. II—(*Concluded from page 617, April 25*)

On April 15 the Automobile Division of the Institution of Mechanical Engineers held a Symposium on Petrol Injection. The papers presented were: "Petrol Injection: Some Further Developments," by E. W. Downing, A.M.I.Mech.E.; "The Status of Automotive Petrol Injection in the United States of America: Spring of 1958," by Errol J. Gay,† and "Petrol Injection in Germany," by Dr.-Ing. H. Heinrich‡ and Dipl.-Ing. H. Stoll.‡ The first paper followed on that of Barrington and Downing (Automobile Division Proceedings 1949-50, page 133) and gave an account of the development and performance of the Jaguar installation described and illustrated on November 1 last, page 631. The last paper and the discussion we abstract below.*

PETROL INJECTION IN GERMANY§

PROGRESSIVE development up to about 1930 is characterised by the fact that brief attempts at a standard system of petrol injection were always nullified by new developments in engine design, carburetter systems, and fuel grades. The first series production, so far as we know, of a petrol-injection pump in a stationary petrol engine made in 1898–1901 by the Gas Engine Works, Deutz, with a total production of 300 pumps, can be traced directly to the imperfections inherent in the surface carburetter in use at that time. The engine was run on paraffin oil whose boiling point was below that of kerosene used now, but the development of the jet carburetter by Wilhelm Maybach and new types of fuel quickly brought about the discontinuance of that type. Even the successes achieved with petrol injection in aero-engines between 1910 and 1920 were never so outstanding that they could not be equalled by carburetters within a short period.

Another factor was the absence of scientific and practical fundamentals for the production of an operationally safe petrol-injection equipment at that time. By 1930–35, however, research into the process of metering the fuel by the carburetter and into mixture formation had progressed to such an extent that the actual potentialities of the carburetter on two-stroke and four-stroke engines were clearly recognised. This marked the period at which development work began on the individual types of petrol engines in order to evaluate the physical potentialities of fuel injection in relation to the carburation system.

THE TWO-STROKE AUTOMOBILE ENGINE

On the assumption that, as an injection engine, the two-stroke engine provided the greatest possibility of improvement compared with the carburetter type, Bosch as far back as the years 1935–39 commenced bench tests and driving tests with a 700 c.c. water-cooled two-cylinder DKW engine with reverse scavenging. Since considerable quantities of unburnt gas are lost even in efficient scavenging processes, as shown in Fig. 1, an appreciable reduction in consumption was to be expected from the injection system as a result of the decrease in fuel losses during the scavenging process, particularly at full load. Owing to its lower weight and the resulting lower overall weight of the vehicle, the two-stroke petrol engine has a consumption advantage over an identically powerful four-stroke engine, even with an identical consumption, grammes per horsepower-hour.

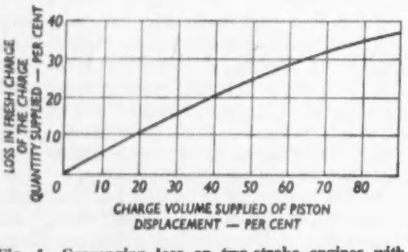

LOSS IN FRESH CHARGE OF THE CHARGE QUANTITY SUPPLIED — PER CENT
40
30
20
10
0
10 20 30 40 50 60 70 80
CHARGE VOLUME SUPPLIED OF PISTON DISPLACEMENT — PER CENT

Fig. 1—Scavenging loss on two-stroke engines with reverse scavenging system

Moreover, the two-stroke engine offers advantages owing to the reduction in standing costs in countries where the annual tax is based on rating (cubic capacity). Another important feature is the lower friction horsepower of the two-stroke engine resulting in considerably more favourable specific consumption values. It is for this reason that after 1945 the experimental programme for the two-stroke engine was again tackled by Bosch, partly in collaboration with the respective engine manufacturers.

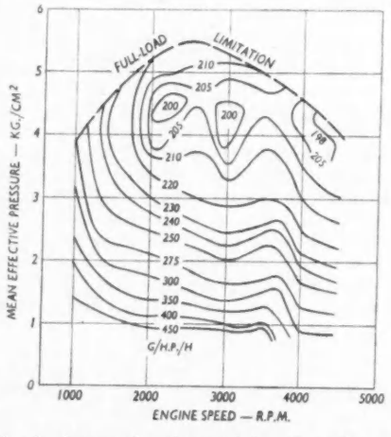


Fig. 2—Consumption characteristics of a 700 c.c. two-stroke engine with petrol injection

Results of Experiments.—Injection from the cylinder head into the cylinder on all these engines was near bottom dead centre (b.d.c.), that is, still during the bypass of the air from the crankcase into the cylinder. A later commencement of delivery gave inadequate intermixture. In fact, notwithstanding injection before closing the outlet slots, fuel scavenging losses occurred only when the fuel was injected in the direction of the outlet slots, which was owing to the field only participating in the air flow to any large extent after vaporisation, and the scavenging process at b.d.c. and low speed having already progressed considerably. Vaporisation of the fuel takes about 2 to 10×10^{-3} seconds while the jet velocity is of the order of magnitude of 50–100m per second. Injection into the cylinder provides better values than injection through the transfer port, the direction and angle of jet in the latter case being too limited.

Uniflow scavenging is not suitable for injection since the co-orientated air flow is unable to distribute the fuel vapour in the cylinder uniformly at full load; even at part load, satisfactory consumption values are obtained only with two or more sparking plugs.

In cross-scavenging with deflector pistons, the output values of the carburetter system are exceeded by about 5–10 per cent only if the combustion chamber is so formed that the major portion of the space available at the top dead centre (t.d.c.) is situated on the inlet side. Mixture formation in cross-scavening is often inadequate, this being noticeable by exhaust glow. On the other hand, improvement in consumption frequently amounts to as much as 50 per cent so that values of about 240 grammes per horsepower-hour are reached without regard to the lubricating oil added separately.

Reverse scavenging is the most suitable of the scavenging systems in use on the carburetter engine. At an octane rating of 80, the compression of 6·5 in carburetter engines can then be increased to 8·0 with injection, resulting in the output and consumption values illustrated in Figs. 2 and 3. As shown in Fig. 2 on a water-cooled 700 c.c. two-cylinder engine, consumption over a fairly wide characteristic output range is between 200 and 220 grammes per horsepower-hour. Fig. 3 provides a comparison for a 200 c.c. motor-cycle engine between the carburetter and the injection system; in actual driving, the injection-engine performance is considerably more lively on account of the higher output, yet fuel economy is more favourable by well over 1 litre per 100km than with the carburetter. The average road consumption dropped from 9 litres with a carburetter to 7·3 litres with an injection system.

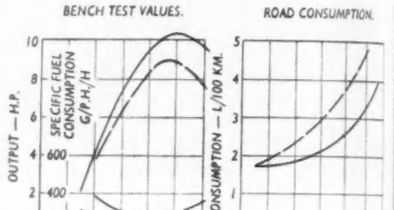


Fig. 3—Comparison between injection and carburetter performance on a 200 c.c. motor-cycle engine

Practical Experience.—The change-over from the large aero pump with pump speed of 1500 r.p.m. and full-load quantities up to 600 cubic millimetres per stroke to the small automobile pump with speeds up to 7000 r.p.m. and full-load quantities which on small cylinder units amount to only 10 cubic millimetres per stroke, necessitated a good deal of meticulous research although the difficulties were overcome by good filtration, special cam shapes and measures of production technique. About 30,000 units of the equipment illustrated in Fig. 4 were delivered, and each one of the fuel-injection pumps checked by Bosch after having covered a distance of 100,000km (62,500 miles) was still found to be within the tolerance specified for a new pump. In isolated instances, coke deposits made it necessary to clean the nozzle outlet occasionally.

Any misgiving that the simple design of the two-stroke engine might be affected by the precision components of the injection equip-

* Joseph Lucas, Ltd., Birmingham.
† Consulting engineer, Associated Ethyl Company, Ltd., London, Thompson Products Incorporated, Cleveland.
‡ Robert Bosch, G.m.b.H., Stuttgart.
§ The photographs illustrating this paper were provided by Dr. Hans Heinrich, Robert Bosch, G.m.b.H.

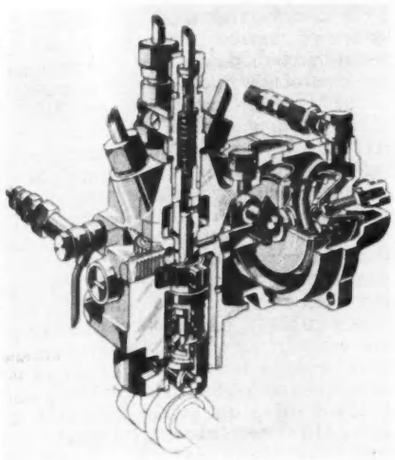


Fig. 4—Injection pump for the GP700E two-cylinder "Goliath" engine

ment was soon dispelled because, apart from the periodically essential oil check of the cam chamber, the equipment functioned without requiring any maintenance whatever. An oil pump took care of engine lubrication since the fuel was no longer delivered through the crankcase, thus doing away with mixture lubrication; direct liner lubrication, at the same time, provided more favourable oil consumption values than feed through the manifold. Oil consumption at that time was generally more than 4 per cent of fuel consumption; present developments of oil additives might bring a noticeable improvement in this high oil consumption and the resultant troublesome coloration of exhaust vapours. An indicator lamp operated by the lubricator provided an adequate safety factor.

Difficulties regarding mixture formation, however, were also frequently encountered in reverse scavenging, particularly after increasing the cubic capacity of the cylinders. The top of Fig. 5 depicts the cause of intermittently occurring knocks. In this series of diagrams, simultaneous measurements were taken of the light-phenomenon in the combustion chamber by means of a photo-electric cell attached to the combustion chamber, and of the pressure variation in the combustion chamber by means of a quartz indicator. In a speed range of about 3300 r.p.m., mixture formation was very poor at small load. Even with ample fuel feed, combustion of any appreciable intensity occurred only once every two strokes. A reduction in the fuel quantity delivered worsened the combustion process, as shown in the second diagram strip. It frequently

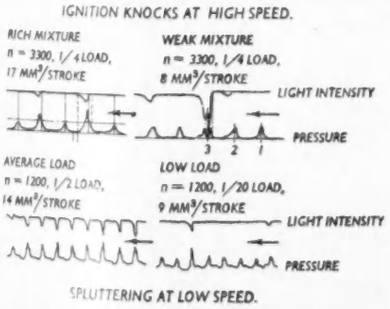


Fig. 5—Difficulties in combustion on a two-stroke engine with reverse scavenging system

happened that a misfire (*a*) was succeeded by delayed combustion (*b*) which caused the next injection (*c*) to ignite during the compression stroke. The turbulence occurring during the injection was a contributory factor. Poor mixture formation under idling conditions as indicated at the bottom of Fig. 5 shows, on the other hand, the cause of troublesome spluttering; whereas combustion proceeds with appreciable regularity at higher load, successive misfiring at small load leads to a gradual mixture congestion, giving rise to single ignitions of almost full-load intensity.

Such difficulties can be fundamentally overcome only by modification of the engine system. Reverse scavenging doubtless makes for favourable mixture ratios in carburetter operation. In injection operation, on the other hand, the cross-scavenging system illustrated in Fig. 6 should be more suitable. Whereas on injection engines with reverse scavenging a high-exhaust gas and weak-fuel mixture remain, in fact, in the plane of symmetry in which the sparking plug is also located, the plane of symmetry in cross-reverse scavenging has a high air content so that the fuel, on account of the shallow trough in the piston head (Fig. 6), remains in

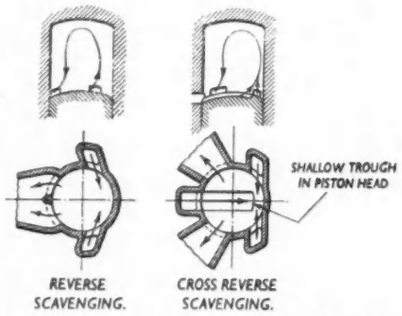


Fig. 6—Arrangement of scavenging duct with reverse scavenging and cross reverse scavenging

this plane even during idling. The resultant stratification at part load makes for a better rate of air flow and consequent elimination of spluttering, and the large scavenging cross sections promise favourable values at high speeds. Whether a perfect stratification without air control down to idling is feasible cannot be predicted without making tests. Continuation of petrol injection on the two-stroke engine depends on whether further improvements of the scavenging process are possible which, however, would probably require rather costly experiments. This might lead to scavenging systems which are not always adaptable to carburetter engines. The economic aspect is a further item to bear in mind in such experiments; cylinder injection, that is, a relatively costly injection equipment, will always be the only practicable system for two-stroke injection.

The Four-Stroke Automobile Engine

Test Results.—In addition to petrol injection for aero-engines, since 1935 Bosch have gone thoroughly into the problem of injection for four-stroke automobile engines. The improvement attainable with injection without any modification on the engine as compared with the carburetter system is relatively small. This is based on the fact that owing to the better utilisation of the heat of vaporisation, the charge remains cooler, and the choke resistance caused by the carburetter is eliminated. At full load, in particular at high speed, this makes for a better charge and it follows that the consumption factor is better in the full-load range as compared with carburetter operation. Improved consumption in the part-load sector, however, can be achieved only if there is irregular fuel distribution to the individual cylinders in carburetter operation.

The main advantages of injection, however, lie in the fact that the manifold is relieved of the task of distributing the fuel uniformly to the individual cylinders and in having full scope regarding manifold diameter, length of manifold, and valve timing. The limitations of manifold modification become apparent, for example, when enlarging the manifold for the purpose of increasing the efficiency in carburetter operation; although the manifold is still too narrow at high speed, the loss of power already occurs at low speed owing to irregular fuel distribution to the individual cylinders. Satisfactory results are therefore obtained on the four-stroke engine only with cylinder injection or with injection at the entrance of the suction valves; in collective injection with a common nozzle, a carburetter-like manifold moistening sets in after a short time, so that a high air velocity and manifold heating cannot be dispensed with even with very fine atomisation.

The requirements relating to commencement of delivery, spray angle, and injection period are very low when the fuel is injected in front of the valves; having regard to a good response of the engine, however, good atomisation is desirable so as to keep manifold moistening as low as possible. The requirements for cylinder injection are higher regarding commencement of delivery, spray angle, and injection period because again, as on the two-stroke engine, the air charge when flowing into the cylinder has to take care of the mixture formation. Under ordinary driving conditions, compression can be increased by an average of 1 to 1·5 units owing to the more uniform fuel feed and better internal cooling.

To summarise, it was established in these experiments that the main attraction of the four-stroke automobile engine regarding injection was its increase in performance due to the modification potentialities on manifold, valve timing, and compression. Further important features are the improved response of the engine and the more favourable acceleration values due to better control of fuel feed at load and speed variations. Fuel saving on the four-stroke automobile engine is a factor of minor importance, being of the magnitude of 10 per cent.

Experience in Practice.—It was in the sphere of engines for racing cars that interest in the four-stroke petrol-injection engine was first shown between 1948 and 1953. Engines designed by Daimler-Benz, Borgward, and BMW being non-supercharged engines, with cylinder injection, reached performances of partly above 100 h.p. per litre cylinder capacity. The racing successes obtained with petrol injection by Daimler-Benz are well known.‖

The results obtained on the engine for the racing car were successfully applied to the sports car types; it was as early as 1955 that the period of acceleration on the 300 SL was clocked at 8·9 seconds from 0 to 100km per hour (62½ m.p.h.), 0·7 second having to be deducted for the change from first to second gear. This represents a value that must be considered as very fair for the unit power of about 6 kg per horsepower.

A performance comparison between the injection system and the multi-choke carburetter tested on the same engine shows that the gain in power below 1200 r.p.m. and above 4000 r.p.m. is considerable and illustrates, in particular, the advantages of the injection engine with regard to commanding a wider speed range. The greater the number of carburetters, the smaller the advantage of the injection system; on the other hand, the difficulty of control increases with the increase in the number of carburetters.

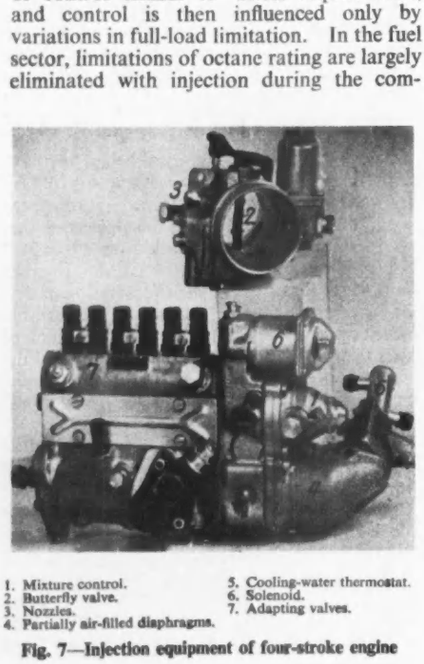
‖ The Engineer, May 20, 1955, page 702.

Since the conditions for simplified injection open up possibilities for reducing the cost of the injection equipment, Daimler-Benz are at present using a manifold injection equipment on their car, type 300d. The output loss in manifold injection compared with cylinder injection on this type of engine is only of any consequence above the speed of 5000 r.p.m., and then amounts to between 2 and 4 per cent.

On four-stroke automobile engines Bosch also use the injection system known in connection with diesel engines, as on aero-engines and two-stroke automobile engines.

The Petrol-Injection Engine with Fuel Stratification

In the field of two-stroke and four-stroke engines in Germany, the production stage has so far been reached only for injection engines on which the air flowing into the cylinder is used for mixture formation and fuel distribution. In the course of the progressive development of the injection engine, it has become increasingly tempting to design the combustion chamber and petrol intake in such a way that, similar to the diesel engine, air control could be obviated. This method would represent a simplification of control similar to diesel requirements, and control is then influenced only by variations in full-load limitation. In the fuel sector, limitations of octane rating are largely eliminated with injection during the compression stroke, and the boiling range could be extended upward by about 100 deg. Cent.



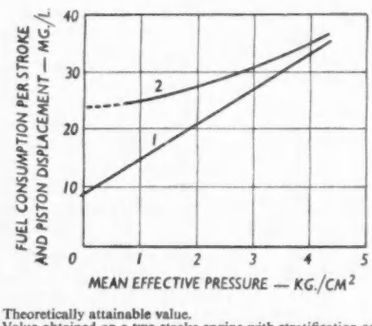
1. Mixture control.
2. Butterfly valve.
3. Nozzles.
4. Partially air-filled diaphragms.
5. Cooling-water thermostat.
6. Solenoid.
7. Adapting valves.

Fig. 7—Injection equipment of four-stroke engine

Experiments on the four-stroke engine have so far been unsatisfactory although those carried out by Bosch have only been on a tentative scale. In compression-stroke turbulence by means of a constriction of the combustion chamber forming a separate turbulence chamber, air utilisation, and thus effective pressure at full load, was inferior to injection during the suction stroke by at least 10 per cent. When utilising the jet energy for mixture formation, very wide injection timing ranges were essential along the speed range; at high speeds, the mixing period was too short and it was found, above all, that the demands on injection characteristics are higher than on the diesel engine. Rotation of the air charge greatly simplifies air utilisation and mixture formation, and in the compression zone of 1 : 10 to 1 : 12 the combustion speed is considerably higher, making for easier compensation of difficulties in mixture formation.

Conditions are more favourable on the two-stroke engine, as the controlled course of residual turbulence allows an earlier intake charge of the petrol. Test results were repeatedly obtained in which air control was dispensed with almost down to idling. The engine then ran perfectly smoothly and without misfiring although it is difficult to attain the theoretical consumption values. Those of the Gutbrod engine in Fig. 8 show that idling consumption without air control is approximately 300 per cent above the theoretical value.

A change-over from reverse scavenging to cross-reverse scavenging might also provide certain advantages although the gains in the fuel sector regarding boiling conditions and octane rating are lost in this type of stratification owing to the petrol injection taking place in b.d.c. The longer mixing period, however, will provide the possibility of higher speeds.



1. Theoretically attainable value.
2. Value obtained on a two-stroke engine with stratification combustion.

Fig. 8—Consumption of a two-stroke engine with apparent stratification combustion

With the present-day utilisation of tar fuels and fuels of the medium boiling range in the boiler fuel, marine and jet units, we do not think that the fuel principle on the stratification engine is any longer of such decisive importance as to give hope of economic advantages in the development of an engine with compression-stroke injection.

Mixture Control Conditions in the Petrol-Injection Engine

In contrast with the engine having fuel stratification where it is not essential to adjust a uniform mass ratio between petrol and air quantity since the volume of fuel-charged combustion chamber varies as a function of the load, the control conditions on other types of engines have a fundamental influence on consumption, running, and performance. It would be no exaggeration to say that they are even more important than the injection method itself.

The aero-engine presents the simplest problem. The output through the propeller produces a relationship between engine speed and engine load such as enables the use of a control device which need function with precision only within a relatively narrow limit. Nor is the additional consumption when accelerating of great importance so long as the richness of the mixture is not sufficient to delay the commencement of combustion. Charging pressure, manifold temperature, and barometric level are covered by individual pick-up devices.

The aim on the automobile engine was to achieve a load range as wide as possible with the best running characteristics and consumption at any normal speed. Since the petrol-injection system for the four-stroke engine is first and foremost adopted on high-priced cars it must, in addition to its advantages in regard to performance and consumption, be equivalent at least to the special types of carburetter used, particularly so in its driving characteristics. Fig. 7 shows the petrol-injection pump with pneumatic mixture control now fitted as standard equipment on the Mercedes-Benz engine, type 300d.

The diaphragm unit of the mixture control (1) in Fig. 7, responds to the vacuum prevailing behind butterfly valve (2), thus producing an approximately constant mixture ratio between petrol and air. The nozzles (3) marked in the Venturi control unit correct this mixture ratio at low load and low speed. Ambient temperature and barometer readings are taken care of by the partially air-filled diaphragms (4). The cooling-water thermostat serves for temperature-dependent increase in the mixture richness, and to increase the idling mixture quantity at low temperature. When starting an engine from cold, the solenoid (6) coupled with the motor forces the control rod to excess delivery; it is controlled via a thermo-switch and is therefore not effective when the engine is hot. The arrangement of the delivery characteristics of the petrol-injection pump in relation to the speed by means of special adapting valves (7) renders unnecessary an otherwise essential additional mechanical speed adaptation, as well as a mixture-enriching device at engine speeds below 1090 r.p.m. Acceleration devices can be avoided by keeping the volume low in the pneumatic control device, as well as reducing manifold moistening by means of a suitable spray direction of the nozzles.

DISCUSSION

Mr. W. M. Heynes (Jaguar Cars, Ltd.) pointed out that high cost was not a bar to an improvement in cars, as the adoption of automatic transmissions showed. Fuel injection promised engines which would have a wider working speed range; the result would be that fewer gears were needed and a lighter vehicle would result. In addition, superchargers would become a practical possibility. That fuel injection had a really marked effect on the engine was shown by the fact that a 300 h.p. Jaguar with fuel injection could be driven in town like a low-powered car.

Mr. P. Bedale (Thornton Research Centre) queried Mr. Gay's finding of better distribution of tetra-ethyl lead with fuel injection. He emphasised that it was necessary for an engine using fuel injection to be designed for that system. Could the control system be made to regulate the air flow to suit the fuel flow, instead of vice versa? This might give a tendency to richness on acceleration instead of, as at present, the opposite.

Mr. C. L. Goodacre (Associated Ethyl Company) presented some of the lessons learned by Chevrolet engineers from their use of fuel injection. He asked whether those fuel injection cars that had been sold had not been bought by oil companies. It was his opinion that the horsepower race had ended because the contemporary push-rod V-8s had reached their limit running normally aspirated on the present-day fuels. He inquired whether valve timings had been changed when petrol injection was used; it appeared to him doubtful whether any significant improvement in performance was obtained.

Mr. Downing confirmed Mr. Heynes's belief that the use of timed injection would allow supercharged engines to use valve overlap, and, hence, give higher output with improved economy. To Mr. Bedale he pointed out that systems in which the driver controlled the air flow were quite capable of giving a satisfactory performance. Mr. Goodacre, he observed, was comparing the

steady state characteristics of carburetted and petrol injection engines ; in transient conditions the advantage of the injection engine was most marked, and resulted in superior acceleration of the car.

Mr. Gay answered Mr. Haynes by saying that the improvement in the Chevrolet effected by fuel injection did not appear to the purchaser to be worth its extra cost. He informed Mr. Bedale that the improved distribution of the anti-knock agent had been found to be worth 1½ octane numbers under certain conditions. He agreed with Mr. Goodacre that many of the fuel injection cars had been bought by oil companies for technical investigations, but he thought that the horsepower race had been stopped because the cars were becoming less safe, and unsuitable for stock car racing. On competition " Corvette " models the valve timing was altered, and the Ford petrol injection cars also had different camshafts, mainly to exploit the extra torque available at high revolutions per minute. He looked forward to a gain of perhaps 18 per cent in efficiency at road load with mechanically- or exhaust-turbine-driven superchargers.

Dr. Heinrich elaborated the comparison between engines with fuel injection and with multiple carburetters by relating that a fuel injection system would be found to be accurately tuned after eighteen months' service, which would not be true of multiple carburetters. He assured Mr. Bedale that it was possible to make air flow the dependent variable.

Mr. J. N. Morris (S.U. Carburetter Company) considered Mr. Gay's figures for petrol injection systems in use misleading ; 20,000 Simmonds Aerocessories installations were in service on U.S. Army vehicles. He believed that there was a distinct drop in octane requirement when fuel injection was used ; Continental Aviation and Engineering Corporation had been able to raise the compression ratio by one unit, due roughly equally to improved fuel distribution and to dispensing with charge heating. He believed that on a two-stroke injection timing was critical ; he asked whether the " Goliath " installation was or was not still in production.

Dr. D. J. K. Stuart (Austin Motor Company, Ltd.) believed, apparently, that there was no substitute for litres. He thought that the control system on the " Goliath " engine would be inadequate because it responded to the total air inspired and not to that trapped in the combustion space.

Mr. R. G. West (Rolls-Royce, Ltd.) thought that it would be difficult to pay for a fuel injection system out of the savings in fuel, while the increases in power could probably be obtained with carburation. Would not idling suffer with the Lucas system due to leakage past the moving parts ?

Mr. W. E. W. Nicolls (C.A.V., Ltd.) considered the results of petrol injection on the two-stroke disappointing. He would have liked to see the evidence on which Dr. Heinrich made the statement that the two-stroke was superior in efficiency ; this was probably because roller bearings were an invariable feature. He believed that stratification must be achieved if misfiring was to be eliminated. He did not understand Dr. Heinrich's reference to the future prospects of stratification ; if it were to be developed successfully, it would establish the two-stroke system and solve all the control problems, since fuel alone would have to be regulated. Eight years ago he had experience of a control system which regulated the air flow ; however, if manifold depression was used to energise the control system, control deteriorated at full torque.

Mr. Downing pointed out to Dr. Stuart that, except for a slight compromise during warming up, it was possible to set a fuel injection system to run consistently on the most efficient point of the consumption loops. He assured Mr. West that leakage at idling was not great enough to change the air/fuel ratio by more than one unit either way.

Mr. Gay informed Mr. Morris that the AV–1790 Continental engine¶ to which he referred had a very long manifold and correspondingly poor mixture distribution.

Dr. Heinrich observed that the two-stroke was indeed a difficult engine to develop, and that the scavenging was the first feature to study.

Mr. C. H. Fisher (Zenith Carburetter Company, Ltd.) asked what were the running clearances of the shuttle in the Lucas distributor. He expressed surprise at the American use of bimetal thermostats secured at both ends, which he thought prejudicial to the spring qualities. He believed that the difficulties of applying fuel injection would be greater on small engines than on large, and that the cost of fuel injection equipment would be even more prohibitive in this country than in the United States of America. As a carburetter engineer, he was sure that carburetters could have a much better performance if more money was spent on them.

Mr. K. T. Arter (Esso Research) observed that the efficiency of a combustion process was fundamentally limited by the efficiency of mixing the reagents. The highly volatile fuels that had been developed for carburetted engines would handicap fuel injection systems. Another disadvantage of these systems was that, unlike carburetters, they metered fuel purely by volume ; the specific gravity of automotive fuels in Europe varied between 0·72 and 0·78. He also queried Dr. Heinrich's views on the prospects of charge stratification in the two-stroke.

Mr. G. Whitehurst (Lexington Products, Ltd.) believed that the cost of fuel injection did not rule it out for quantity-produced vehicles ; the system with which he was familiar was expected to cost between £5 and £6 at a production rate of 100,000 per year, and tooling costs would be about £70,000. He produced test results to show that petrol injection could improve the performance of a British 1390 c.c. car engine (reproduced as Figs. 5, 6, 7 and 8 on pages 667 and 668).

Mr. Downing replied to Mr. Fisher without giving measurements of working clearances, stating only that they would be two to three times greater than those of a diesel injection pump. Distribution would be consistent between cylinders to within ±2 per cent, and a fuel saving of 10 per cent could be anticipated. He illustrated how great an improvement over carburation was possible by producing results which showed that in small samples of nominally identical cars the air/fuel ratio, determined by exhaust gas analysis, might vary by three or four units. To Mr. Arter he responded that an injection system could be designed to be free of vapour lock on any likely fuel.

Mr. Gay explained that bimetal strips were, at one end, only loosely secured.

Dr. Heinrich clarified his reference to fuels for engines with charge stratification by saying that stratification might allow fuels with an octane number as low as 60 to be used, and piston engines might then share the fuel of aircraft gas turbines. The carburetter would remain in use, he felt sure, for the foreseeable future.

¶ An upright air-cooled V-12 of 1790 cubic inch capacity giving 810 h.p. gross, used on tanks and self-propelled guns.—ED. THE E.

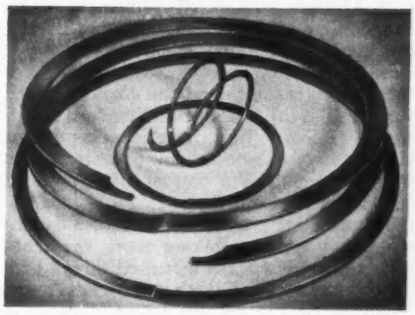
Circular Retainers

BY means of an agreement recently effected with the Ramsey Corporation of St. Louis, Wellworthy, Ltd., has been granted the sole selling rights to manufacture and distribute the " Spirolox " retaining ring in England and certain other countries.

The ring consists of a double turn or spiral of hardened, tempered and polished top-grade spring steel which has rounded edges to prevent fretting of grooves. It is crimped in the space between the two ends so that it lies flat in its groove.

If the retaining ring is designed to spring outwards into a housing, the free outside diameter exceeds the closed or working diameter by a calculated amount, and for an inspringing ring the free bore diameter is correspondingly smaller than the shaft groove diameter.

" Spirolox " are provided with notches or slots at each end for removal, and an ordinary screwdriver is all that is required. Fitting is extremely simple. One end of the retaining ring is put into the groove and the whole ring is then wound or spiralled in. As the last end enters, there is a definite " snap " which indicates that the ring is properly fitted. For removal, one end is eased out of the groove with a screwdriver and the retaining ring is then unwound. Assembly line fitting can be speedily carried out by means of simple tapered plugs or sleeves which allow the retaining rings to be pushed straight into their grooves.



Spiral retaining rings which have a perfectly circular projection and can be fitted and removed without special tools. Notice the different endings

In the " Spirolox" ring, it will be obvious that the absence of any ears or lugs saves space and may avoid special machining, particularly with inspringing shaft retaining rings. Also, the bearing surface is increased owing to the absence of gap, and the full concentricity of the " Spirolox " ensures even circumferential loading all round the groove. As well as being much safer in static applications, this feature of concentricity ensures almost perfect dynamic balance on rotating shafts.

The normal size range is from ¼in diameter upwards, and whereas 10in is the normal upper limit of diameter, much larger diameters are possible without expensive tooling costs.

Diameters and thicknesses are related as far as possible to existing standard groove sizes ; " Spirolox " are manufactured in normal and specially thick series where large side thrusts have to be considered.

We learn from Wellworthy, Ltd., that the positive displacement compressors, originally built for oil engine applications (see page 156, Aug., 3, 1956) are now being sold in large quantities, not as superchargers, but to provide the working air for the discharge systems of bulk transport vehicles handling flour and similar freights.

PETROLEUM FIRES.—We are informed that a new film, entitled " Fire Under Control," has been made and covers all aspects of petroleum fires in home, workshop and refinery. It illustrates the most effective ways of controlling and extinguishing fires. Copies of this 16mm sound and colour film, which has a running time of twenty-three minutes, may be borrowed from the Mobil Film Library, Sound Services, Ltd., 269, Kingston Road, London, S.W.19.

Tightening and Tensile Tests on Joints

By J. E. FIELD*

No. I

The static strengths of B.S.W., B.S.F., UNC. and UNF. bolt-nut combinations have been compared under various conditions of tightening, with a particular view to checking the suitability of UNF. threads for general use. Tests were carried out under single and repeated tightening, and some of the nuts were bored out to simulate conditions resulting from the use of an oversize tapping drill. While the UNF. combinations were at least as strong as the other types for a single tightening, many of them failed by thread bending and stripping and they were not so resistant to repeated tightening as the other types. For satisfactory use of UNF. combinations, tightening must not be sufficient to cause yield. It is suggested that UNC. threads would generally be preferable in heavy applications where close control of tightening is not possible. In changing over from Whitworth to Unified threads, each case should be considered on its merits, and UNF. should not be taken as an automatic replacement for B.S.F.

Introduction

Owing to thread stripping failures, encountered under service conditions with Unified Fine (UNF.) threads, where British Standard Fine (B.S.F.) threads had previously been found to be satisfactory, it was decided to compare the static strengths of these two types of thread and also of Unified Coarse (UNC.) and British Standard Whitworth (B.S.W.) threads, under conditions similar to those found in practice. The fatigue strength of a bolt of given nominal size of thread form is not much affected by the thread pitch, as has been shown experimentally,[1] and as follows from the theoretical analysis [2] : the increased thread load concentration for fine threads tends to be balanced by the corresponding increase in core area of the bolt.

The static tests were carried out on commercial high-tensile bolts (Code R) and appropriate nuts (Code P), subjected to various degrees of tightening as the clamping members of a steel joint.

It is recommended in the British Standards for Precision Hexagon Bolts, Screws, Nuts and Plain Washers, Nos. 1083 : 1951 (Whitworth) and 1768 : 1951 (Unified), that Code R bolts (45 to 55 tons per square inch) should be used with Code A nuts (28 tons per square inch minimum, Brinell Hardness Number 120/235 approximately). In these tests, Code P nuts (35 to 48 tons per square inch, Brinell Hardness Number 152/235 approximately) were used, in order to narrow the range of variation of nut hardness, and because it was felt, from previous experience, that nuts near the bottom of the Code A hardness range would be too soft to develop the full strength of Code R bolts for all types of thread.

Class 2 (Unified) and the corresponding Medium Fit (Whitworth) bolts and nuts were used, these being the classes of fit normally employed in high-grade engineering work. Since it has been found[3] that increase of effective diameter clearance causes a serious decrease of thread stripping strength, any deficiencies of fine threads in this respect would be even more pronounced in Class 1 or Free Fit threads.

The sizes chosen were $\frac{3}{8}$in, $\frac{3}{4}$in and 1$\frac{1}{2}$in, increasing by a factor of 2 in each case. The diameter/pitch (D/p) ratio increases fairly regularly with size for all four types of thread up to 1$\frac{1}{2}$in, except for UNF., where the pitch is constant at $^1/_{12}$in from 1in to 1$\frac{1}{2}$in diameter. For this reason, the D/p ratio for 1$\frac{1}{2}$–12 UNF. threads is abnormally high (=18·0), and it was thought desirable to check the strength of such threads. The D/p ratios for $\frac{3}{8}$–24 UNF. and $\frac{3}{4}$–16 UNF. (equal to 9·0 and 12·0 respectively) are also on the high side of the mean UNF. curve of D/p against diameter, and any tendency to thread stripping would be expected to be rather more pronounced in these than in adjacent sizes.

TABLE I—*Bolt Sizes and Manufacturers*

Nominal size and number of threads per in	$\frac{D}{p}$	Length of bolt, in	Symbol representing manufacturer	
			Bolt	Nut
$\frac{3}{8}$–24 UNF.	9·0	2	A	F
$\frac{3}{8}$–20 B.S.F.	7·5	2	A	F
$\frac{3}{8}$–16 UNC.	6·0	2	B	F
$\frac{3}{8}$–16 B.S.W.	6·0	2	A	F
$\frac{3}{4}$–16 UNF.	12·0	3	A	F
$\frac{3}{4}$–12 B.S.F.	9·0	3	D, E*	F
$\frac{3}{4}$–10 UNC.	7·5	3	C	F
$\frac{3}{4}$–10 B.S.W.	7·5	3	C	F
1$\frac{1}{2}$–12 UNF.	18·0	5	C	F
1$\frac{1}{2}$–8 B.S.F.	12·0	5	C	F
1$\frac{1}{2}$–6 UNC.	9·0	5	C	F
1$\frac{1}{2}$–6 B.S.W.	9·0	5	C	F

* The bolts from manufacturer E were used only for repeated tightening tests.

Description of Bolts and Nuts

All the bolts were Code R (45 to 55 tons per square inch), and all the nuts Ordinary Code P (35 to 48 tons per square inch),

TABLE II—*Summary of Results of Tightening and Tensile Tests on $\frac{3}{8}$in Threads*
(Code R bolts + Code P nuts)

Type of thread	Average hardness of bolts/nuts HD/30	Tightening torque test to failure (no external tensile load)			Tensile test to failure, (no pretightening)*		Tensile test to failure of joint pretightened to 90 per cent of maximum torque (col. 2)*			
		Yield torque, lb-in	Maximum torque, lb-in	Mode of failure	Maximum load, tons	Mode of failure	Pretightening torque, lb-in	Maximum load, tons	Mode of failure	Load for joint separation, tons
	1	2	3	4	5	6	7	8	9	10
$\frac{3}{8}$–16 B.S.W.	250 / 220	350 (+70) (−40)	400 (+80) (−40)	B(6)	4·5 (+0·2) (−0·4)	B(6)	360 P(3) + E(3)	4·4 (±0·2)	B(6)	3·7 (+0·3) (−0·6)
$\frac{3}{8}$–20 B.S.F.	280 / 200	405 (+15) (−35)	500 (+50) (−40)	B(5) + N(1)	4·6 (±0·2)	B(5) + N(1)	450 P(6)†	406 (+0·1) (−0·2)	B(5) + N(1)	3·6 (±0·1)
$\frac{3}{8}$–16 UNC.	230 / 200	400 (±20)	445 (±30)	B(6)	4·3 (±0·1)	B(6)	4·5 P(6)	4·2 (±0·1)	B(5) + N(1)	3·1 (+0·4) (−0·6)
$\frac{3}{8}$–24 UNF.	250 / 200	415 (+35) (−25)	525 (+100) (−125)	B(2) + N(4)	4·5 (+0·2) (−0·9)	N(6)	475 P(6)	4·4 (±0·2)	N(6)	3·7 (±0·6)

TABLE III—*Summary of Results of Tightening and Tensile Tests on $\frac{3}{4}$in Threads*
(Code R bolts + Code P nuts)

Type of thread	Average hardness of bolts/nuts HD/30	Tightening torque test to failure (no external tensile load)			Tensile test to failure (no pretightening)*		Tensile test to failure of joint pretightened to 75 per cent of maximum torque (col. 2)*				Tensile test to failure of joint pretightened to 90 per cent of maximum torque (col. 2)*			
		Yield torque, lb-in	Maximum torque, lb-in	Mode of failure	Maximum load, tons	Mode of failure	Pretightening torque, lb-in	Maximum load, tons	Mode of failure	Load for joint separation, tons	Pretightening torque, lb-in	Maximum load, tons	Mode of failure	Load for joint separation, tons
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
$\frac{3}{4}$–10 B.S.W.	250 / 200	2650 (+450) (−400)	3310 (+310) (−290)	B(6)	17·3 (+0·9) (−0·6)	B(6)	2480 E(6)	17·2 (+0·9) (−1·0)	B(6)	9·4 (+0·5) (−1·1)	2980 P(6)	16·8 (+0·7) (−0·5)	B(6)	9·7 (+0·5) (−0·3)
$\frac{3}{4}$–12 B.S.F.	200 / 200	3210 (+290) (−310)	4280 (+440) (−480)	B(6)	18·6 (+1·0) (−1·3)	B(6)	3210 P(4) + E(2)	17·8 (+1·2) (−1·6)	B(6)	12·0 (+1·0) (−0·7)	3850 P(6)	18·4 (+1·6) (−0·9)	B(6)	14·0 (+1·5) (−1·3)
$\frac{3}{4}$–10 UNC.	260 / 210	3420 (+180) (−60)	4130 (+210) (−230)	B(6)	17·6 (+0·7) (−0·9)	B(6)	3100 E(6)	17·5 (+0·6)	B(6)	12·7 (+0·5) (−0·8)	3715 P(6)	17·4 (+0·6) (−0·9)	B(6)	13·9 (+0·3) (−0·4)
$\frac{3}{4}$–16 UNF.	250 / 200	3650 (+410) (−1080)	5080 (+800) (−1060)	B(2) + N(4)	21·1 (+1·1) (−0·6)	B(4) + N(2)	3810 P(2) + E(4)	20·5 (+0·5) (−0·7)	B(2) + N(3)	17·0 (+1·0) (−0·8)	4570 P(6)	20·6 (+1·1) (−0·7)	B(2) + N(5)	18·6 (+0·7) (−0·6)

(for notes see after Table IV)

* Mechanics and Materials Division, Mechanical Engineering Research Laboratory, East Kilbride.

obtained from a commercial stockist. The bolts, including the threads, were covered with a thin adherent black scale. The nuts were bright. The sizes of the bolt heads and of the nuts conformed to the appropriate British Standard (1083 : 1951 for B.S.W. and B.S.F., and 1768 : 1951 for UNC. and UNF.). All the bolts and nuts were stated to be Class 2 (Unified) or Medium Fit (Whitworth). The threaded lengths of the bolts were about half the total shank lengths.

The sizes investigated, with symbols representing manufacturers, are listed in Table I.

Metallographic Examination

One bolt was selected from each of the thirteen types listed in the penultimate column

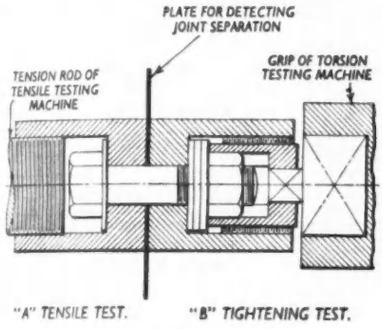


PLATE FOR DETECTING JOINT SEPARATION
GRIP OF TORSION TESTING MACHINE
TENSION ROD OF TENSILE TESTING MACHINE
"A" TENSILE TEST.
"B" TIGHTENING TEST.

Fig. 1—Methods of Test

of Table I. (The ¾in B.S.F. bolts were from two manufacturers.) An axial section was prepared through the threaded portion of each bolt, and this was polished and etched to show the grain structure. The ⅜in bolts showed evidence of having been produced by rolling, in that there were seams in some of the thread crests. None of the bolts, however, showed any tendency to "grain flow" following the thread contour, so that, in the bolts investigated, any such effect due to the threads being produced by rolling must have been removed during the heat-treatment normally carried out after rolling in order to obtain the requisite static tensile strength. (Sometimes only a stress relief is carried out after rolling, and this does not usually remove the "grain flow" completely.) No serious decarburisation was observed in any case. For a given size of bolt, the grain size was similar for all four types. It was rather finer for the ⅜in bolts than for the larger ones.

There appears, therefore, to have been on significant metallurgical differences between the various types of bolt investigated.

All the nuts were obtained from a single manufacturer.

Hardness Tests

Standard diamond pyramid hardness tests were carried out on most of the ⅜in and ¾in bolts and nuts, and on six bolts and six nuts of each type in the 1½in size.

The hardness variations within any particular batch of nuts were not very great, and all the nuts were well within the values quoted in the above-mentioned British Standards for Code P material.

Large variations were often obtained in the hardness numbers for a particular bolt, and the average values for some of the bolts appeared to be below the minimum hardness for Code R material. However, in the tensile tests subsequently carried out, no case was found of a bolt falling below the minimum tensile strength† of 45 tons per square inch for Code R. The hardness values are not, therefore, a reliable guide to the strength of the bolts.

The average hardness values obtained are included in Tables II, III and IV.

Tightening and Tensile Tests

In the principal series of tests, a bolt and nut were used to fasten together a pair of steel adaptors, which could be fitted to the grips of a tensile testing machine for applying external load to the joint (see Fig. 1). Torque could be applied to the combination by means of hexagon sockets fitting over the bolt head and nut and connected to a static torsion testing machine. Six combinations of each type were tested, in each size. Before test, the threads were brushed to clean off loose matter ; this did not disturb the scale on the bolts. The threads and the bearing faces of the nut and underlying washer were then coated with a light grease.

The main group of tests comprised tightening tests to failure and tensile tests on pre-tightened joints, in each case with the application of a single tightening. In the first case, the nut was tightened continuously on the bolt in a static torsion testing machine, at an approximately constant rotational speed of 90 deg. per minute, to determine the yield torque and the maximum torque developed before failure ; for brevity, the latter is referred to below as "failure torque."

The tensile tests to failure were made on combinations tightened by hand only, and to 75 per cent and to 90 per cent, respectively, of the average failure torque for a particular size and type of thread ; in the latter two conditions, the tensile load to separate the joint was determined in addition to the maximum load, by noting when a flat plate, interposed between the adaptors, just became loose.

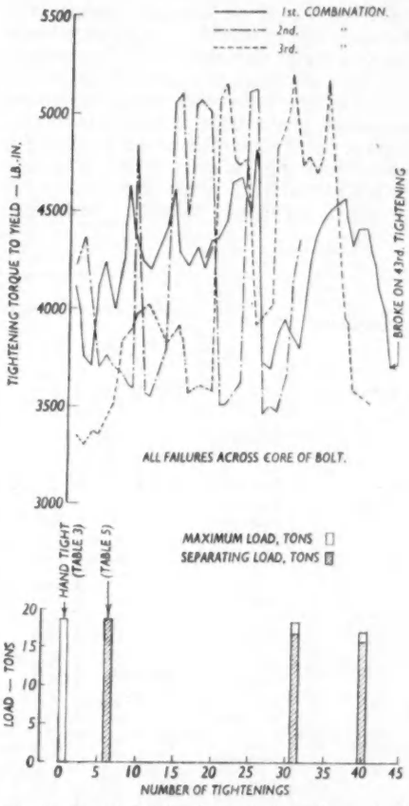


Fig. 2—Repeated tightening tests to yield on ¾—12 B.S.F. combinations (Group 6)

It has been shown that tightening to yield develops maximum clamping load and has no adverse effects for coarse threads.[4] On the other hand, it is not desirable to tighten to far above the yield. Thus, in the ⅜in size, as the yield, for all types of thread, exceeded 75 per cent of average failure torque, this tightening condition was not investigated; again, in the 1½in size, as the yield was invariably less than 75 per cent of average failure torque, this condition was investigated

† Based on "stress area"

$$= \pi\left(\frac{\text{effective diameter} + \text{minor diameter}}{4}\right)^2$$

Table IV—*Summary of Results of Tightening and Tensile Tests on 1½in Threads*

(Code R bolts+Code P nuts)

Type of thread	Average hardness of bolts/nuts HD/30	Tightening torque test to failure (no external tensile load)			Tensile test to failure (no pre-tightening)*		Tensile test to failure of joint pretightened to 75 per cent of maximum torque (col. 2)*			
		Yield torque, lb-in	Maximum torque lb-in	Mode of failure	Maximum load, tons	Mode of failure	Pretightening torque, lb-in	Maximum load, tons	Mode of failure	Load for joint separation, tons
	1	2	3	4	5	6	7	8	9	10
1½-6 B.S.W.	260 / 190	21,250 (+2,450) (−1,750)	34,200 (+4,800) (−3,400)	B (6)	72·7 (+3·4) (−2·9)	B(5) + N(1)	25,650 E(6)	70·6 (+5·8) (−3·7)	B (6)	54·9 (+5·8) (−2·9)
1½-8 B.S.F.	240 / 200	27,420 (+2,980) (−3,020)	46,200 (+3,600) (−3,200)	B (6)	75·1 (+3·3) (−1·8)	N (6)	34,650 E(6)	78·4 (+4·1) (−5·0)	B(3) N(3)	64·6 (+2·4) (−4·6)
1½-6 UNC.	235 / 210	21,050 (+950) (−550)	38,850 (+1,850) (−2,850)	B (6)	73·0 (+3·4) (−3·4)	B(5) + N(1)	29,150 E(6)	72·2 (+5·05) (−2·8)	B (6)	54·0 (+1·8) (−1·5)
1½-12 UNF.	235 / 200	21,230 (+1,470 (−1,430)	47,300 (+4,700 (−2,700)	N (6)	75·6 (+3·2) (−7·1)	N (6)	35,625 E(6)	75·1 (+3·3) (−3·4)	N (6)	62·15 (+3·35) (−3·65)

Notes on Tables II, III and IV

* In general, no definite yield observed in the tensile tests. Two of the hand-tight ½–10 B.S.W. bolts yielded at 15·5 tons, and three of the hand-tight ½–10 UNC. bolts at 15·7 tons approximately. All the ¾in assemblies (B.S.W., B.S.F., UNC. and UNF.) gave a very indefinite yield at about 4 tons, and the 1½–12 UNF. assemblies at about 55 tons (thread bending).

B—failure across core of threaded portion of bolt, with appreciable necking. No, or only slight, bending of bolt threads.

N—failure by stripping of nut threads, with considerable bending of bolt threads, generally accompanied by slight necking of bolt. Number in brackets indicates number of assemblies failing in manner indicated.

P—yield of bolt and/or nut occurred before reaching stated pretightening torque. Torquing continued until latter was reached.

E—stated pretightening torque reached without appreciable yielding.

† In addition, two bolts broke during pretightening before the torque of 450 lb-in was reached (Table II).

N.B.—All threads were lubricated with Shell Retinax A, a light grease.

and not the one involving a more severe tightening. Both conditions were investigated in the ¾in size. The results of the above tests are reported in Tables II, III and IV.

Some similar tightening and tensile tests were carried out on ¾in combinations with bored-out nuts, to simulate conditions resulting from use of an oversize tapping drill. For each type of thread, the nuts were bored out to a minor diameter, which, in conjunction with the average measured major diameters of the bolts with which they were assembled, gave a depth of engagement equal to 50 per cent of the full thread height for a bolt of basic size, as given in B.S. 84 : 1956 for B.S.W. and B.S.F., and in B.S. 1580 : 1953 for UNC. and UNF. threads. Determinations were made of failure torque and of tensile loads for joint separation and failure after tightening to 75 per cent of failure torque for normal combinations. The latter type of test was also extended to include joints tightened up to a maximum of seven times, joint separating loads being determined after each tightening, with final application of tensile load to failure. The results of the tests with bored-out nuts are reported in Table VI.

A fuller investigation was also made of the effect of repeated tightening on normal combinations in the ¾in size. First, tests involving only seven tightenings were carried out, the nut being tightened on the bolt in a static torsion testing machine until yield occurred. After the sixth tightening, the tensile load for joint separation was determined. The nut was then completely removed to permit inspection of the threads (as also after the fifth tightening). Finally, the combination was tightened to failure. The results of these tests are reported in Table V.

As these latter tests showed a tendency for thread bending to occur in the UNF. combinations, it was decided to carry out further tests, involving a much greater number of tightenings. Three combinations of each type were tested. The first was repeatedly tightened to yield until failure occurred. The second and third combinations were repeatedly tightened in the same way, but for a somewhat smaller number of tightenings,

TABLE V—*Results of Repeated Tightening Tests on Normal ¾in Combinations*

Combination		Applied torque, for successive tightenings, lb-in								Joint separating load after sixth tightening, tons	Maximum failure torque on seventh tightening, lb-in	Damage after fifth tightening*	Damage after sixth tightening*	Mode of final failure†
			1	2	3	4	5	6	7					
¾–10 B.S.W.	(1)	Yield	3100	3000	3000	2900	3000	3300	3000	13·3	3120	No thread bending. Bolt necked by 0·007in	As after fifth tightening	B
		Breakloose	2100	1950	1920	1800	1840	2130	—					
	(2)	Yield	3000	3200	2900	2820	2860	3200	3300	13·7	3860	No thread bending. Bolt necked by 0·004in	As after fifth tightening	B
		Breakloose	2260	2040	1960	1900	1940	2360	—					
	(3)	Yield	3150	2900	2900	2900	2900	2800	2600	13·9	3040	No thread bending. Bolt necked by 0·004in	As after fifth tightening	B
		Breakloose	1980	1900	1900	1900	1900	1600	—					
¾–12 B.S.F.	(1)	Yield	4200	4000	4100	3910	4300	4500	3100	18·7	3290	No thread bending. Bolt necked by 0·010in	As after fifth tightening	B
		Breakloose	3000	2800	3000	2750	3000	2900	—					
	(2)	Yield	4700	4380	4400	4300	4280	4450	3150	17·6	3780	No thread bending. Bolt necked by 0·010in	No thread bending. Bolt necked by 0·013in	B
		Breakloose	3400	3200	3200	3200	3200	3450	—					
	(3)	Yield	4200	4200	4480	4150	3700	3700	3550	19·2	3930	No thread bending. Diameter not checked	No thread bending. Bolt necked by 0·020in	B
		Breakloose	3050	2850	2750	2400	2650	2550	—					
¾–10 UNC.	(1)	Yield	3050	2900	2900	2900	2900	2900	2800	16·0	3100	No thread bending. Bolt necked by 0·009in	No thread bending. Bolt necked by 0·013in	B
		Breakloose	2100	1800	1800	1750	1750	1600	—					
	(2)	Yield	2700	2740	2720	2780	2740	2480	2700	14·4	2990	No thread bending. Bolt necked by 0·006in	No thread bending. Bolt necked by 0·008in	B
		Breakloose	1880	1760	1740	1700	1700	1350	—					
	(3)	Yield	2750	2750	2800	2900	2750	2650	2850	14·7	3120	No thread bending. Bolt necked by 0·007in	As after fifth tightening	B
		Breakloose	1750	1700	1750	1700	1700	1600	—					
¾–16 UNF.	(1)	Yield	4000	4000	3600	3600	3400	3600	3700	18·2	3900	Bolt threads slightly bent. Bolt necked by 0·009in	Bolt threads rather more bent. Bolt necked by 0·009in	N
		Breakloose	3150	2700	2700	2700	2500	2900	—					
	(2)	Yield	3600	3200	3200	3200	3300	3250	3250	18·0	3690	Bolt threads slightly bent. Bolt necked by 0·009in	Bolt threads slightly bent. Bolt necked by 0·009in	N
		Breakloose	3100	2600	2450	2450	2450	2450	—					
	(3)	Yield	3600	3230	3300	3370	3500	3400	3250	18·4	3400	Bolt threads slightly bent. Bolt necked by 0·005in	Bolt threads slightly bent. Bolt necked by 0·006in	N
		Breakloose	2900	2600	2600	2600	2750	2700	—					

* Nut threads not easy to observe, but probably bent if bolt threads were bent.
† The necking of the bolt at fracture was considerable for B.S.W., B.S.F. and UNC. The necking of the UNF. bolts after stripping failure was only a few $^{1}/_{1000}$ in more than after the sixth tightening.

TABLE VI—*Summary of Results of Tightening and Tensile Tests on ¾in Bolts Assembled with Bored-Out Nuts*

(Code R bolts+Code P nuts ; both Class 2 or medium fit, except that nut minor diameters were oversize, to give depths of engagement equal to 50 per cent of full thread height of basic size bolt).

Type of thread	Tightening torque test to failure (no external tensile load)			Tensile test to failure of joint pretightened once to 75 per cent of maximum torque for normal combinations				Tensile test to failure of joint pretightened seven times to 75 per cent of maximum torque for normal combinations (Col. 4)			
	Yield torque, lb-in	Maximum torque, lb-in	Mode of failure	Pretightening torque, lb-in	Maximum tensile load, tons	Mode of failure	Load for joint separation, tons	Load for joint separation after sixth tightening, tons	Load for joint separation after seventh tightening, tons	Maximum tensile load after seventh tightening, tons	Mode of failure
	1	2	3	4	5	6	7	8	9	10	11
¾–10 B.S.W.	3160 (+320) (−220)	3750 (+240) (−220)	B(3)	2480 E(6)	16·9 (+1·1) (−0·9)	B(6)	7·9 (+0·4) (−0·6)	8·8 (±0·8)	8·5 (+0·7) (−0·5) (5 results)*	17·4 (+0·4) (5 results)*	B(6)
¾–12 B.S.F.	3760 (+470) (−400)	5180 (+40) (−50)	B(3)	3210 E(6)	17·2 (+0·5) (−0·8)	B(5) + b(1)	11·1 (+0·6) (−0·9)	12·5 (+0·9) (−0·7)	12·8 (+0·8) (−0·6)	17·2 (+0·7) (−0·6)	B(3) + n(3)
¾–10 UNC.	Indefinite	3640 (+240) (−320)	B(2) + b(1) (severe hacking)	3100 P(4) (+2 indefinite)	16·6 (+0·9) (−1·8)	B(5) + b(1)	13·7 (+1·0) (−0·9)	13·2 (+0·8) (−1·2) (4 results)†	14·5 (+0·4) (−0·2) (3 results)†	16·9 (±0·4) (3 results)†	B(5) + b(1)
¾–16 UNF.	Indefinite	4190 (+270) (−240)	N(3)	3810 (Yield indefinite)	19·3 (+1·0) (−1·5)	n(6)	16·5 (+0·8)	Pretightening torque = 3650 lb-in‡			
								15·2 (±0·5)	15·8 (±0·4) (2 results)§	19·0 (+1·3) (−1·4) (2 results)§	b(2) + n(1)
								Pretightening torque = 3210 lb-in			
								12·6 (+1·0) (−0·6)	13·5 (+0·6) (−1·2)	18·5 (+0·5) (−0·6)	b(3) (necking very slight)

Notes on Table VI

B—Failure across core of threaded portion of bolt, with marked necking.
N—Failure by stripping (bending and shearing) of nut threads, with considerable bending of bolt threads and only slight necking of bolt.
b—Failure by stripping of bolt threads. Both nut and bolt threads badly bent. Some necking of bolt.
n—Failure by stripping of both bolt and nut threads, with only slight necking of bolt.

} Number in brackets shows number of assemblies failing in manner indicated.

E—Stated pretightening torque reached without appreciable yielding.
P—Yield occurred before reaching stated pretightening torque. Torquing continued until latter was reached.
*—One bolt broke during seventh tightening.
†—Two bolts failed on second and sixth tightenings, respectively, and a third bolt failed on seventh tightening.
‡—Of three assemblies tightened to 3810 lb-in, two failed by stripping on the second tightening and one at the tensile separating load of 14·5 tons, after the sixth tightening (b).
§—One bolt failed on seventh tightening (b).

Note that : 3650 lb-in = average yield torque for normal ¾–16 UNF. combinations. 3210 lb-in = average yield torque for normal ¾–12 B.S.F. combinations.

after which the tensile loads for joint separation and for failure were determined. In this manner, a check was obtained on the extent of the loss of clamping load due to a large number of tightenings. The results of these tests are plotted in Figs. 2 to 5.

Finally, an attempt was made to obtain similar information for repeated tightening to fixed torque values, again using ¾in combinations. As the maximum speed of the torsion testing machine was only a quarter turn per minute, the torque was applied in these tests by a limiting-moment torque spanner, the

TABLE VIII—*Limits of Variation of Results of Tightening and Tensile Tests in all Three Sizes*

	Maximum percentage variations from mean value of				
	Yield torque	Maximum failure torque	Tensile failure load	Tensile load for joint separation after pre-tightening to 75 per cent of maximum failure torque	Tensile load for joint separation after pre-tightening to 90 per cent of maximum failure torque
B.S.W.	+20 −15	+20 −10	+5 −9	+9 −12	+8 −16
B.S.F.	±11	+10 −11	+5 −7	+8 −7	+11 −9
UNC.	±5	±7	+5	+4 −6	+13 −19
UNF.	+11 −30	+19 −24	+5 −20	±6	±16

TABLE VII—*Repeated Tightening Tests on Normal ¾in Combinations, Using a Torque Spanner*

Type of combination	Tightening torque, lb-in	First Combination			Second Combination			Third Combination		
		No. of tightenings	Necking of bolt, in	Other damage to combination	No. of tightenings	Necking of bolt, in	Other damage to combination	No. of tightenings	Necking of bolt, in	Other damage to combination
¾–10 B.S.W.	2500	50 51	0·031 —	None Bolt core failure	70 80 150	0·023 0·024 0·024	None None None	40 120 160	0·023 0·023 0·024	None None None
	2750	20 150	0·0005 0·0005	None None	60 150	0·0005 0·001	None None			
	3000	50 150	0·001 0·0015	None None	50 150	0·003 0·004	None None			
	3250	50 150	0·007 0·007	None None	50 150	0·002 0·0025	None None			
	3500	50 150 250	0·013 0·040 0·060	None None None	50 100 150	0·008 0·008 0·010	None None None	20 50 150	0·011 0·014 0·015	None None None
¾–12 B.S.F.	3000	60 120 240	0·0005 0·004 0·006	None None None	100 150 200	0·0005 0·0005 0·0005	None None None			
	3250	150	0·002	None	100 240 360	0·016 0·051 0·071	None None None	50 100 150	0·001 0·001 0·002	None None None
¾–10 UNC.	3000	20 180 240	0·012 0·027 0·028	None None None	150 200	0·0 0·0	None None			
	3250	7	—	Bolt core failure	50 100 150	0·043 0·047 0·047	None None None	50 80	0·016 —	None Bolt core failure
¾–16 UNF.	3000	60 160	0·0 0·0005	None None	40 150	0·001 0·001	None None			
	3250	40 80 87	0·0005 0·0005 0·0005	Bolt threads slightly bent Bolt threads more bent Thread stripping failure	30 60 70 90 148	0·003 0·004 0·0045 0·005 0·005	Bolt threads slightly bent Bolt threads slightly bent Bolt threads more bent Bolt threads more bent Thread stripping failure			
	3500	10 20	0·011 0·011	Not inspected Thread stripping failure	15 18 19	0·014 0·014 0·014	Bolt threads slightly bent Bolt threads more bent Thread stripping failure			

Note : Where the bolt threads were bent, it is probable that the nut threads were also bent. Observation of the threads inside the nut was difficult.

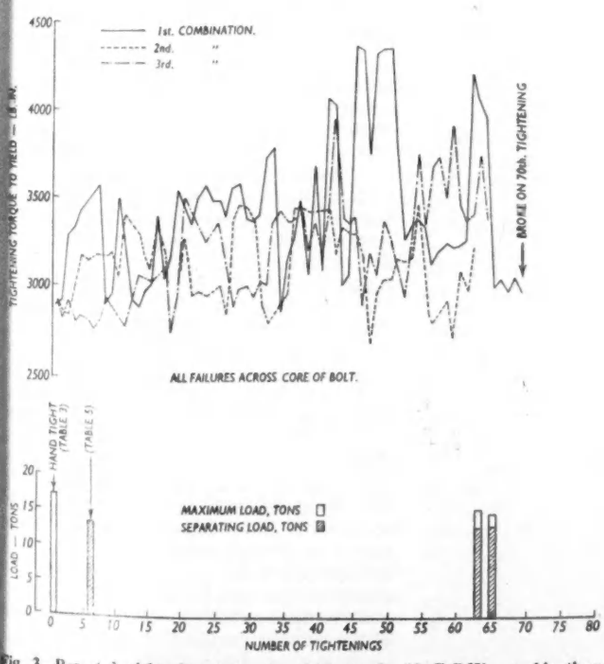


Fig. 3—Repeated tightening tests to yield on ¾—10 B.S.W. combinations (Group 6)

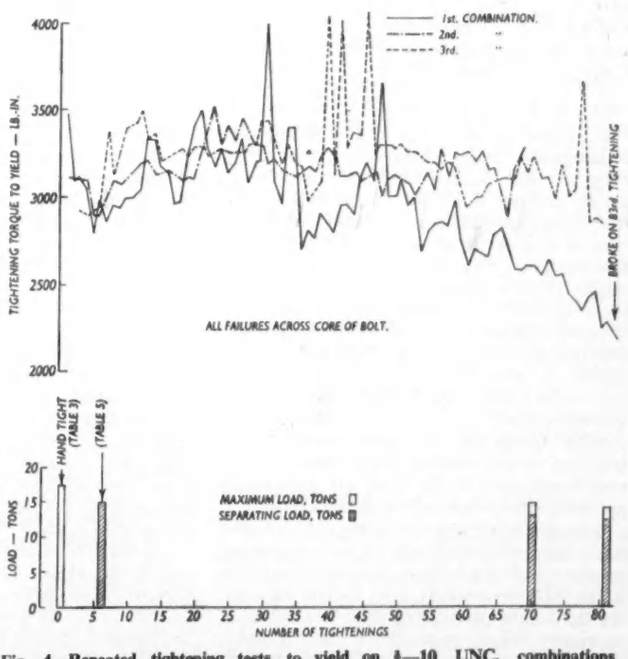


Fig. 4—Repeated tightening tests to yield on ¾—10 UNC. combinations (Group 6)

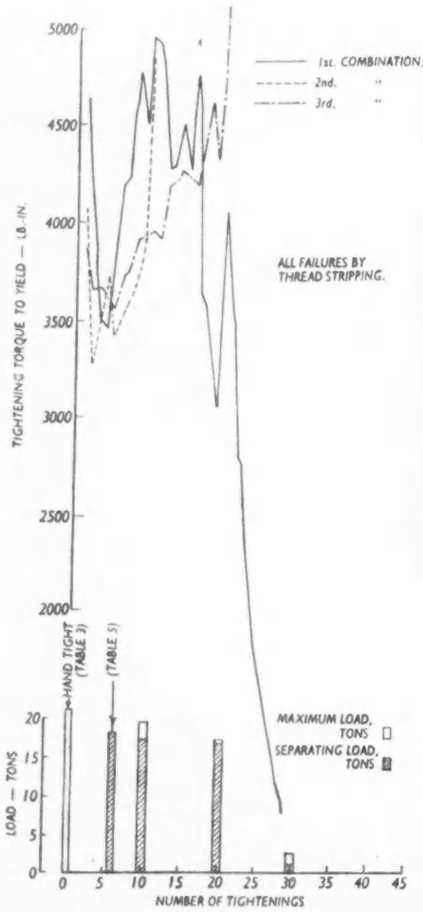


Fig. 5—Repeated tightening tests to yield on ⅜—16 UNF. combinations (Group 6)

setting of this being continually checked against the torsion testing machine. A plain steel block was used in place of the joint adaptors, with a plain washer under the nut. The results of these tests are reported in Table VII.

Discussion of Results

The bolt tensile strengths, determined during the main series of tests, were all within the Code R specification values of 45/55 tons per square inch and the hardness values of the nuts were all well within the Code P specification values.

Variability of Results

It should be observed at the outset that although the total number of tests was large, only six tests were, in general, carried out under any particular set of conditions, and that there was considerable variability in the results obtained. It is, therefore, possible that the average values and limits of variation might have been somewhat different from those quoted in the tables, if the tests had covered a larger number of samples. Certain conclusions may still be drawn from the results, as to differences between the types and sizes of thread investigated, but the quoted values should only be taken as a general indication of those likely to be obtained in practice under a particular set of conditions, even if the latter are thought to approximate to those of the present tests.

The limits of variation for the different main types of test, Tables II to IV, covering results on all three sizes, are summarised in Table VIII for each type of thread. Except for the case of pre-tightening to 90 per cent of maximum failure torque in the ⅜in size, which is not likely to occur very often in practice, the results for UNC. are definitely the most consistent. The results for B.S.W. and UNF. were the most inconsistent, and abnormally low values seemed particularly likely to be encountered with UNF. The scatter of results is further referred to below in considering particular groups of tests.

Mode of Failure

A definite yield, as indicated by a halt in the rise of load with approximately constant rate of strain, was often observed in the tightening tests but not in the tensile tests. Even in the tightening tests, the onset of yield was generally ill-defined, and tended to be masked by the stick-slip movement of the threads ; the quoted values of yield torque are those for which definite yield had occurred.

The B.S.W. and UNC. combination in all three sizes and the B.S.F. combination in the ⅜in and ½in sizes, generally failed by breakage across the core of the bolt. Many of the UNF. combinations in the smaller sizes, and all in the 1½in size, failed by stripping of the nut threads, with severe bending of the bolt threads. These differences may be largely explained as in the Appendix on a basis of pitch and diameter and of certain other factors. It may be mentioned here that the relatively low height of the 1½in Unified nuts, as compared with that of the 1½in Whitworth nuts, increased the tendency to stripping failure of UNF. combinations, already most pronounced in the larger sizes.

The stripping failures took place more gradually than the bolt core failures, and for a given rate of strain, the torque or tensile load fell off more gradually in the stripping case. This means that severe over-tightening might occur during assembly without being detected, for those combinations susceptible to failure by thread stripping, i.e. for the UNF. combinations.

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(To be concluded)

Metallurgical Aspects of Nuclear Power Engineering

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No. II—(*Continued from page 615, April 25*)

The basic metallurgy associated with nuclear power reactors is described in this article, both for the British emphasis on gas-cooled reactors and the American trend towards liquid cooled reactors. The physical metallurgy of the fissile fuel metals, uranium, plutonium and thorium is described in sufficient detail for the interesting behaviour of these materials under reactor conditions, particularly irradiation and corrosion, to be appreciated. Possible explanations of the mechanisms of these unusual effects are reviewed. Methods of developing fuel elements, with a view to minimising difficulties experienced in reactor operation, are then briefly reviewed. This field covers the use of alloys of the fissile metals, present and possible future methods of canning fuel elements and the increasing interest in ceramic and cermet fuels. Development of certain non-fissile metals and alloys for use in reactor construction has been rapid. These developments are outlined and the effects of irradiation and dry, wet and liquid-metal corrosion, on the properties of non-fissile materials are discussed. The applications of physical metallurgy to reactor development are emphasised but, where appropriate, the production techniques for some of the special materials are introduced.

Behaviour of Fissile Metals Under Irradiation

EVERYTHING in the core of a nuelear reactor is bombarded by radiation, principally neutrons, which produces damage of two main types. By knocking atoms out of their equilibrium lattice positions direct damage is caused. When irradiation changes the atomic nuclei, in effect producing new elements or allotropes, indirect damage is caused.

Neutrons, being electrically neutral, pass through an atom, unconcerned about the electrical fields of the nucleus or the electron cloud. Consequently, most neutrons pass straight through an atom without disturbance to the path of the neutron or to the position of the atom concerned. Occasionally, a neutron hits the nucleus of an atom, but the proportion of the neutron flux to do so is very small because of the smallness of the target presented by the nucleus. The cross section of the nucleus target varies widely from one type of nucleus to another and also with the speed of the neutrons and the type of collision taking place. It is thus a more complex quantity than the fundamental projected area of a nucleus. In general, cross sections may be expected to vary inversely as the neutron velocity, since the shorter the time for which the neutron is in the immediate vicinity of the nucleus, the smaller its chance of interaction. In other words, a slow neutron is more likely to be influenced by the minute attractions between masses than is a fast neutron, so a given nucleus spreads its influence over a larger area than its physical projected area to slow neutrons but not to fast ones. In addition, resonance can occur between the energy of vibration of an atom and a neutron having a certain critical energy level, or velocity. When this occurs, it is tantamount to saying that the system "atom nucleus plus neutron" is preferred to the energy of the nucleus alone. Since many more neutrons are likely to be affected by such a resonance condition, the effective cross section of the nucleus suddenly rises at these particular energy levels. To be able to compare one type of nucleus with another, with regard to its effect on neutrons, it is convenient to refer to its effective cross section. It is normal to take the total or maximum possible cross section of a nucleus for interaction of any kind; with fast or slow neutrons and for absorption or scattering, and express it in barns. A barn is a measure of the effective cross section of a nucleus to neutron irradiation and one barn is a unit of 10^{-24} square centimetres. The table below

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lists a few typical neutron capture cross sections, i.e. the maximum cross sections of the nuclei concerned, in barns.

Element	C/s (barns)	Element	C/s (barns)
Deuterium	0·0006	Lithium	65
Beryllium	0·0085	Boron	700
Carbon	0·0048	Cadmium	2500
Magnesium	0·06	—	—
Zirconium	0·18	—	—
Aluminium	0·24	—	—
Iron	2·50	—	—
18/8 Stainless	2·90	—	—

The elements in the left-hand column, particularly the first five, have low effective cross sections and consequently of great interest in moderating neutrons or in structural units in the reactor to conserve neutron economy. On the other hand, elements such as boron and cadmium are capable of "mopping up" neutrons and consequently would be used only in control rods which, by absorbing excess neutrons, hold the chain reaction of a reactor in check.

Two possibilities exist when a neutron does manage to strike a nucleus. The neutron may be deflected from its line of approach to the nucleus or be "scattered," or, alternatively, it may be absorbed into the nucleus.

Scattering

Only fast neutrons (speed about 2 MeV equivalent to 2×10^9 centimetres per second), freshly created from a nuclear fission, produce damage by scattering because only they have sufficient energy to give a large recoil energy to the struck nucleus. A slow, moderated or thermal neutron has an energy of about 0·025 eV (speed about 2×10^5 centimetres per second) whereas the energy necessary to move the average atom from its equilibrium lattice site to become an interstitial atom and leave behind it a vacant site, is about 25 eV.[4] Thus, a thermal neutron has insufficient energy to eject atoms from their lattice sites. However, a fast neutron has an enormous excess of energy to do this and, of course, the ejected atoms will receive very high energies after the collision. So much so, that they may well collide with another atom and displace it; the process continuing until the energy has been reduced below that necessary to eject an atom from its site.

Absorption

Another source of high energy particles is the result of an atom absorbing a neutron. The new nucleus formed is usually unstable and, in an attempt to recover equilibrium, it may emit, (i) a quantum of γ-radiation, (ii) an α-particle or helium nucleus, (iii) a β-particle or electron, or (iv) undergo fission to produce a pair of high energy ions and some high energy neutrons. With the exception of γ-emission, all of the approaches to equilibrium result in the production of a new atom or atoms which then act as chemical impurities in the material. Quite often, the fission fragments are, or quickly decay into, one or another of the inert gases. This impurity, having a very low tendency to enter into solid solution with metals, creates volume increases due to the formation of gas bubbles. Any fission product, irrespective of whether it is a gas or not, will cause an increase in volume if its density is less than that of the parent metal.

Not only will the fission products be energetic immediately after the fission, but additionally many of them will be electrostatically charged. Because of their greater mass the fission products move slowly compared with a neutron of the same energy and, in the case of the ions resulting from fission, their electrostatic charge will interact with other nuclei and electrons and the fission particle will quickly be brought to rest. The fact that fission fragments are quickly brought to rest also means that their energies are dissipated in a much smaller distance than those of neutrons of similar energies. Thus, these fragments produce greater localised damage than do neutrons. Much of the damage will result in displaced atoms. A neutron or fragment producing the first atom displacement is said to have produced a "primary knock-on" and high energy atoms resulting from such collisions may then produce secondary knock-ons. Both primary and secondary knock-ons result in the creation of vacant lattice sites and interstitial atoms, but much of the energy is dissipated as heat. The amount of heat to be dissipated can be fantastic in scale even though it disperses very rapidly and it has been suggested that around a collision area the material melts and freezes again rapidly forming a displacement or thermal spike.[5] During this process, the atomic lattice becomes "shuffled" locally and many of its defects are eliminated. The region freezes back on to its lattice containing a few lattice defects. Even so, with high energy spikes such as result from the action of fission fragments in uranium, a considerable amount of lattice damage accumulates in time.

Annealing of Radiation Damage

When a thermal spike occurs, some of the lattice defects are eliminated by what can be termed self-annealing. Also, other thermal spikes in the vicinity of defects from a previous thermal spike may produce annealing and this can be termed radiation annealing. Finally, ordinary thermal annealing can be employed to eliminate more defects. Self-annealing and radiation annealing can never be completely successful in eliminating radiation damage because both are associated with radiation damage production. The thermal annealing of radiation damaged material is a complex process not yet fully understood, though the fundamental tendency for interstitials and vacancies to diffuse and cancel out exists. It seems fairly certain, however, that the movement of interstitials and vacancies is by no means equally shared. Interstitials have a greater urge to move than vacancies, because the lattice strain surrounding the former is considerably greater than that surrounding a vacancy.

Even when the point defects have been annealed away, some traces of radiation effects remain and metals do not usually fully recover until much higher annealing temperatures are reached than are needed to cancel out most of the point defects.

Alternatives to the Melt/Freeze Spike Theory

Although it is probably the easiest mechanism to picture, the melting of the region of a thermal spike, followed by freezing back on to the surrounding lattice, may well be an over-simplification of the mechanism of neutron damage. It is doubtful if the concepts of melting as visualised under normal conditions up to temperatures of 2000 deg. Cent. can be applied to temperatures which theory predicts should be of the order of millions of degrees, in operation for very short times and over distances of a submicroscopic scale.

Kinchin and Pease[6] suggested that most of the lattice disorder is produced by moving interstitial atoms at the end of a cascade of knock-ons which have sufficient energy to knock other atoms into interstitial positions but not enough to avoid being caught in the vacancies so created. In this way it is possible to picture, at the beginning of a thermal spike, both interstitials and vacancies; the interstitials then moving ahead and as the total energy of the spike runs down the late interstitials getting caught in the vacancies created by their final collisions. The last atoms leaving these vacancies come to rest in interstitial positions some distance from the vacancies (which balance them in numbers) created early in the spike.

Another suggestion by Seitz and Koehler[7] refers to thermal stresses around a spike perhaps being sufficient to cause plastic flow locally and that this may be the source of disordering.

Radiation Effects on Uranium

Much of what has been described so far in this section could be applied equally well to fissile or non-fissile materials. Radiation damage in solid fissile materials, is, in general, more extensive than in non-fissile materials. The fissile materials are as close as possible to the source of radiation because it emanates from them and, in addition, they are concerned with the production of fission fragments. Non-fissile materials receive both neutron and fission fragments at "second-hand." By far the greatest experience of irradiation effects on fissile materials has been gained from uranium.

As one would expect, the amount of damage to uranium increases with time and with the strength of the neutron irradiation; the neutron flux. The kind of damage and its extent are also dependent on the physical state of the uranium and its temperature.

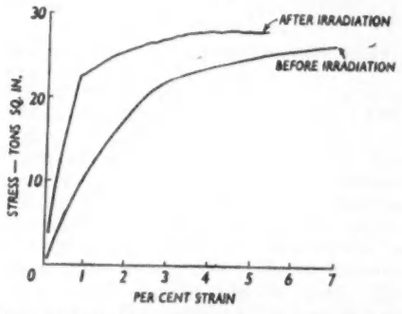

Fig. 4—Effect of irradiation on stress/strain curves of uranium

An example of short-term irradiation is given by the fact that the stress/strain curve of pure uranium exhibits an appreciable elastic limit after irradiation but not before (see Fig. 4). Obviously, if the useful life of a fuel element is going to be extended, the effects of irradiation must be considered and the deleterious effects removed if possible.

The effects of irradiation on uranium fall roughly into two classes depending largely on the temperature of the uranium under irradiation. One class of effects is predominant below 450 deg. Cent. and the other above 450 deg. Cent. At the lower temperatures growth occurs and at higher temperatures swelling is apparent. The distinct difference in meaning of these apparently similar terms will become evident in the following account.

Radiation Growth of Uranium

A single crystal of uranium subjected to irradiation would change shape considerably by extending along its (010) axis, contracting on the (100) axis and leaving the (001) substantially unaltered (see Fig. 5). This growth takes place at constant temperature and should not be confused with growth due to thermal cycling. If a polycrystalline bar

of uranium with crystals having a preferred orientation (010) along the length of the bar is irradiated, the growth will still occur. The bar will grow longer and decrease in diameter. Under the most appropriate conditions for growth; pronounced (010) crystal

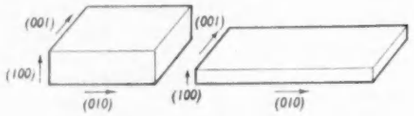

Fig. 5—Radiation growth of uranium

direction orientation along the length of the bar, a high neutron flux and a temperature of 200 deg. Cent., the length can increase by 100 per cent for a 0·2 per cent burn-up of the available fissile atoms. The growth is proportional to the burn-up and a temperature of about 200 deg. Cent. appears to give a maximum effect (see Fig. 6). Growth is also encouraged by a small grain size in highly directional polycrystalline bars. It should be emphasised that the growth described involves virtually no increase in

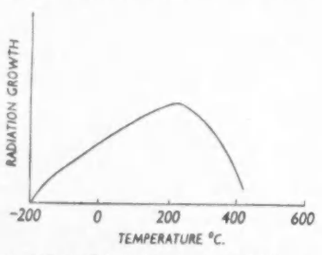

Fig. 6—Effect of temperature on radiation growth

volume in contrast to swelling, which does lead to volume increases and is not particularly directional in its result.

At the surfaces of uranium bars changes in the dimensions of individual grains can take place more freely than they can in grains at the core of the bar. Particularly when some of the grains have their (010) directions oriented at the normal to the surface and when the grain size is large, one would expect to get surface distortions after irradiation. This effect is observed and is called wrinkling. Cast uranium is of random orientation and does not change macroscopically in dimensions on irradiation, but its large grain size does lead to surface wrinkling. An idealised sketch of the wrinkling effect is given in Fig. 7.

To minimise growth it is necessary to

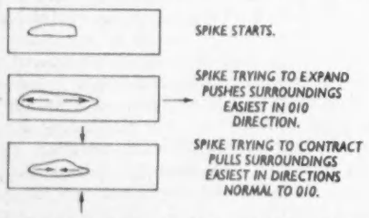
SPIKE STARTS.
SPIKE TRYING TO EXPAND PUSHES SURROUNDINGS EASIEST IN 010 DIRECTION.
SPIKE TRYING TO CONTRACT PULLS SURROUNDINGS EASIEST IN DIRECTIONS NORMAL TO 010.

Fig. 7—Idealised sketch of the wrinkling effect

avoid directional orientation and, as explained in a previous section, this is best achieved by a rapid quench through the β/α transformation; the process known as β-quenching. The response to β-quenching of many dilute binary uranium alloys (up to 3 atomic per cent of alloying element) has been examined and fine random grains can be achieved in many of them. The extents of growth and wrinkling are appreciably reduced by such a structure. It is also possible to achieve random fine grains by powder metallurgy methods.

Theories of Radiation Growth

Two main kinds of theory have been advanced to explain radiation growth of uranium. Both are basically dependent on the anisotropic properties of the metal. One suggests that growth is the result of thermal strains existing in and around thermal spikes. The other, the point defect theory, suggests that growth is a result of the long range migration of lattice defects created by thermal spikes.

Wyatt and Pugh,[8] in putting forward a theory of the first type, assume that the material surrounding the thermal spike is in compression during the intense heating period. Plastic deformation occurs preferentially in the (010) direction of the crystal because of the low compression yield stress in this direction. Cahn[9] showed that below 450 deg. Cent. the (010) crystal axis is associated with a low yield point in compression, although in tension the yield point is relatively high. The reverse effect, high compression yield point and low tensile yield point were found in directions normal to the (010) direction. Thus, in the cooling cycle of the thermal spike the local compressive stresses are replaced by tensile stresses and the uranium then deforms plastically in a direction normal to the (010) direction. The net result of these processes is growth in the (010) direction (see Fig. 8).

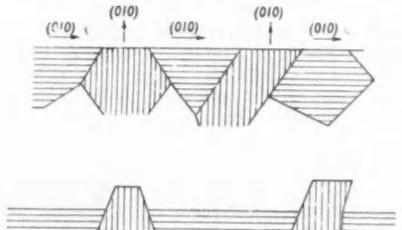

Fig. 8—Spike theory of irradiation deformation

Within a mass of polycrystalline uranium, the extension is accompanied by the gradual distortion of the grains, elongated in the direction of growth.

The main objection to this type of theory is that the lifetime of the thermal spike is short and very little is known about such high rates of stressing that it is taking a lot for granted in assuming that deformation processes proceed as under normal conditions.

The other type of theory is illustrated by that due to Siegle and Opinsky,[10] who suggested that the shape change of uranium occurs by anisotropic diffusion of interstitial atoms and vacancies. The vacancies are assumed to diffuse along (100) axes which results in contraction and the interstitials diffuse along (010) axes resulting in expansion when the interstitial or vacancy runs out at a grain boundary. Alternatively, it has been suggested that vacancies and interstitials segregate preferentially to dislocations with suitable vectors, giving the same end result.

Cottrell[11] has summarised some of the arguments for and against both theories.

Spike Theory

(1) Thermal stresses give adequate driving force for growth. (2) Explain growth fall off at high temperatures by rapid relaxation of small high-strain regions at such temperatures. (3) Do not explain why rate of growth falls off at low temperatures. (4) Do not explain why the (001) axis remains unchanged by irradiation.

Point Defect Theory

(1) It is difficult on this basis to find an adequate driving force for growth. (2) Diffusion of defects is extremely selective and on a very large scale. (3) Rate of growth at low temperatures explained by low mobilities of defects at such temperatures. (4) This theory has to postulate that there are sufficient thermal vacancies at high temperatures to capture interstitials before they can contribute to growth, in order to explain the disappearance of growth at high temperatures. (5) As with the spike theories, the point defect theories do not explain why the (001) axis remains unchanged.

Higher Temperature Effects

At temperatures above about 450 deg. Cent., the radiation damage in uranium is due to different mechanisms from those already described. At these temperatures, development of gas pockets in the uranium becomes evident. This results in a change in volume and is termed swelling.

Because of the fission process, foreign elements are produced in the metal lattice. Some of these elements will be, or will decay radioactively to, the inert gases. A 1 per cent burn-up of 1 cubic centimetre of uranium gives 4·73 cubic centimetres of gas, calculated at N.T.P., but most of this will be contained at high pressure and so the uranium will not expand by 473 per cent. However, the solubility of the inert gases in solid uranium is extremely small and pockets of gas will be formed. It was thought at one time that the gases might diffuse out to the external surface of the uranium during service in a reactor and so escape without causing much swelling. In practice, only a small fraction of the gas does diffuse out at reasonable working temperatures. After prolonged irradiation at high temperatures, the amount of gas voids in uranium is sufficient to cause a large amount of swelling, even as much as 50 per cent at 800 deg. Cent. where the metal is plastic in the γ-phase region. The microstructure of the irradiated metal shows a large amount of gas bubbles. To contain the gas in irradiated uranium without excessive swelling obviously requires a high creep strength at high temperatures. Pure uranium cannot satisfy this condition and so it is necessary to resort to alloys, cermets, ceramics and canning methods to develop sufficient high temperature strength in the fuel element as a unit.

Other Changes During Irradiation[12]

The hardnessof annealed uranium increases markedly during irradiation. A 0·1 per cent burn-up of the uranium atoms results in a hardness increase from about 215 D.P.N. to 315 D.P.N. At the same time uranium develops an appreciably elastic limit, finally becoming quite brittle and prone to cracking in service at low temperatures. The thermal conductivity of uranium, which is important in reactor heat transfer, decreases during irradiation and electrical resistivity increases.

It is fairly obvious that the extent of damage caused by irradiation of uranium is sufficient to limit the life of a fuel element very seriously. This means that fuel elements must be processed frequently to recover active material from the partially burnt-up matrix.

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(To be continued)

Structural Thermal Insulation

Saving in fuel becomes a topical subject of some importance with the advent of the second stage of the Clean Air Act on June 1. A conference dealing with the thermal insulation of factory buildings was held during the recent Factory Equipment Exhibition, and here one of the conference papers is reproduced in abstract. It is by Mr. C. Hammond of Sir W. G. Armstrong Whitworth Aircraft, Ltd., and describes recent installations of thermal insulation in three large factory buildings, and the benefits thus obtained.

IN Armstrong Whitworth Aircraft's factory at Baginton the floor area is 1,300,000 square feet and the cubic content 36,000,000 cubic feet. One can realise from these figures that a sizeable heating plant is required to maintain the factory temperature. Boiler plant is high-pressure hot water with 4/20,000,000 B.Th.U. and 4/9,000,000 B.Th.U. Cochran " Super Economic " boilers burning solid fuel with Hodgkinson mechanical stokers, coal being fed by elevated hoppers to the stokers. Heating mains, of which there are approximately 5½ miles, feed " Carrier York " units floor mounted, each capable of displacing 600,000 B.Th.U., and the total number in the factory is 90.

The outgoing temperature at the units is 140 deg. to 150 deg. Fah. and the air displacement is 7000 cubic feet per minute. Coal consumption before insulation, for the thirty-week period, was approximately 6200 tons per annum. We were unable, with temperature falling below 32 deg. Fah., to maintain the temperature of 65 deg. Fah. asked for, and demand was made for more heating plant. Serious consideration was given not to installing more heating but, if anything, to reducing it by the introduction of structural insulation.

Roof covering throughout the factory comprises corrugated asbestos " Bigsix " and continuous runs of patent glazing, which is typical of many industrial buildings up and down the country.

We found on investigation that, apart from the structural losses of 1·40 B.Th.U. square feet hour for asbestos and 1·00 B.Th.U. square foot hour for glass, considerable losses were taking place through the horizontal and vertical laps of the corrugated sheeting. This amounted to an area of approximately 1500 square feet of open space. It is important when checking the calculations for structural losses to bear the point in mind.

Thermal Insulation Scheme at Baginton

Our first stage of insulation was an office of 63,000 square feet floor area of North light construction, 15ft to eaves, 25ft to ridge, at 25ft span of trusses. The roof covering was asbestos corrugated " Bigsix " sheeting and double runs of patent glazing with ¼in wire cast glass, the whole area being covered by seven spans of roof trusses. The South slopes were insulated under the purlins with Bowater ½in fibre board with " Ardor " aluminium foil stapled to the topside.

The results exceeded expectation : temperatures were easily maintained at 65 deg. to 70 deg. Fah. The existing heating was reduced by 40 per cent and the annual saving was 219 tons of coal. With this experience we embarked on the much larger scheme of insulating the main aircraft assembly building. Using the same method throughout, approximately 80 per cent has been completed.

These buildings were of 150ft span, 30ft to eaves and 55ft to ridge. The same excellent results have been obtained and the saving of solid fuel is 2500–3000 tons per annum. Out of all this a saving of 40 per cent has been obtained and the company will cover its cost of insulation in five to six years, and furthermore, shop temperatures can be easily maintained if required at 65 deg. Fah.

Where work is manual, the workers do not now ask for more than 60 deg. Fah. The reason for this is the complete reduction of what they term draught, wherein the actual cause of discomfort was air change taking place on the large areas of single skin roof covering.

The adoption of the combined fibre board and " Ardor " aluminium foil eliminate solar heat which can be a cause of numerous complaints during the summer periods and can bring about a loss of production due to lassitude, especially in the lower roof areas.

Insulation of Bitteswell Factory

At our Bitteswell factory, which is similar in design to our main aircraft assembly shops at Baginton, right from the drawing board, insulation and the size of the heating plant was finalised. This resulted in a much smaller boiler plant than otherwise would have been required, with an uninsulated building and, therefore, maximum efficiency in the saving of solid fuel was possible. Due to the use of petroleum fuels in complete aircraft, " Asbestolux " ¼in flat sheets were substituted for ½in fibre board and " Ardor " aluminium foil stapled to the topside before under-purlin fixing. This gave a *U* value of 0·18 B.Th.U. hour square foot.

The exposed position of this factory of 106,590 square feet floor area and 3,746,500 cubic feet, the larger areas of doors being opened, 30ft high, at all times of the day for the movement of aircraft and in all types of weather from complete calm to winds gusting at 50–60 m.p.h., brought special reasoning for all types of heating to be introduced to overcome the sudden loss of heat when such large areas of doors of up to 5000 square feet were opened at frequent periods.

It was finally agreed to ignore this reasoning and therefore similar heating units to those at our Baginton factory were fitted and the factory heating provided to maintain an internal temperature of 65 deg. Fah. with an outside temperature of 32 deg. Fah. The insulation proved so effective that no air movement or drop in temperature was felt for periods of up to thirty minutes when the large door areas were exposed.

Engineers who have visited this factory are amazed that, standing within 2ft and in the centre of the large area of door opening, they could feel no air movement inside the building, and the workers feel no effect at all, although temperatures showed a drop of 4 deg. Fah. within fifteen minutes at a time when the internal temperatures were 60 deg. Fah. and external temperatures of 32 deg. Fah. and a wind of 15 m.p.h.

The answer, of course, is very simple. Structural insulation controls the B.Th.U. losses under all conditions and, therefore, heat stored in the large roof area at a much higher temperature than the working level blankets the incoming air and the temperature differences mix for an indefinite period, thus overcoming that sudden draught and discomfort so often met with in an uninsulated factory. The workers are very satisfied here that temperatures of 58 deg. Fah. are the more ideal. This may be accounted for by their much greater movement in and out of the factory when working on the aircraft.

The boiler plant in this factory comprises three Cochran " Economic " boilers with automatic stoking, each boiler of 6,500,000 B.Th.U. rating. At peak loading, the external temperatures at 16 deg. to 32 deg. Fah., only two boilers are required on load, the third boiler being installed to cover boiler cleaning to maintain maximum efficiency.

Insulation of the Whitley Factory

At our Whitley factory, up to a few years ago we had fourteen boiler houses spread over different parts of the factory, mostly hand-fired boilers and burning coal and coke fuels. This is also typical of many old factories where buildings of thirty to forty years of age were used and a boiler house provided to cover each block of buildings. The factory has now been demolished and rebuilt on modern standards with North light buildings with ¼in fibre board and " Ardor " insulation to the South slopes of the roof.

The floor area of 374,500 square feet and volume of 7,183,000 cubic feet is now heated from one boiler house with two Cochran " Economic " boilers of 2/12,500,000 B.Th.U. and one Daniel Adamson 9,000,000 B.Th.U. with coal-fired automatic stoking. This has brought about a considerable fuel saving and, what is most important, burning fuel to its full utilisation value, which cannot be successfully achieved with hand firing.

The cost of all this work spread over five years, including scaffolding, totals £141,750. The savings of insulation over an uninsulated building are 4370 tons per annum of solid fuel costing £21,650. Saving in labour costs at our Whitley factory by the setting up of one main boiler house, replacing the 14 small boiler houses, is approximately £3000 per annum.

Scaffolding costs are interesting to note. In factories where the work is carried out above machinery, jigs, &c., special precautions have to be taken to protect the workers and therefore costs can be as high as 25 per cent of the total contract. This, of course, depends on the size and height of the building. On new buildings the cost can be as low as 2½ to 4 per cent. Here again this depends on the size and height of building and where no special precautions, except for compliance with building regulations, apply.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

NEW STANDARDS FOR RUBBER-INSULATED CABLES

No. 2899. Price 5s. No. 883. Price 15s. On January 1, important changes in British Standards for rubber-insulated cables were made effective by the issue of the following new publications : Amendment No. 3 to B.S. 7, " Rubber-Insulated Cables and Flexible Cords for Electric Power and Lighting " (PD 2935) ; a new edition of B.S. 883 " Cables and Flexible Cords for Electrical Equipment of Ships " ; a new standard, B.S. 2899, " Vulcanised Rubber Insulation and Sheath (including Polychloroprene) of Electric Cables."

This last publication specifies a reduced rubber content for insulation, in accordance with the Recommendations of the 1953 and 1957 Commonwealth Standards Conferences. This reduction is also provided for in the amendment to B.S. 7 (and amendments to other standards relating to rubber-insulated cables) and by the revision of B.S. 883.

LETTERS AND LITERATURE

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

WATER PRESSURE IN CONCRETE DAMS

SIR,—While the conditions for design laid down in the report of the Sub-committee on Uplift in Masonry Dams of the " Committee on Masonry Dams " of the American Society of Civil Engineering, Power Division, 1951 (see *Transactions*, Vol. 117, 1952, page 218), would seem to ensure complete safety for masonry and concrete gravity dams, there appears to be an illogicality in the theoretical treatment, which is not entirely satisfactory, and leads to a significant omission in the treatment of arch dams. For clarity, it may be stated that concrete is invariably assumed to become in course of time completely porous, the rate at which this occurs depending on the density and compaction of the concrete. It follows that a build-up of pressure gradient is created in course of time over the cross-section of the dam, which is controlled by the conditions that the maximum pressure occurs at the upstream face, that at the downstream toe being zero ; the latter, of course, entails constant evaporation or leakage.

The literature on the subject of uplift is considerable, as indeed its importance warrants.

The above assumption is perfectly rational, but its full implication has apparently not been accepted, since two implied conditions have been completely ignored, namely :

(i) That the internal water pressure at any given point is exerted in all directions and not solely in the vertical ; and

(ii) That the cohesive force binding the cement colloids together is not taken into account, when assuming that full uplift occurs over 100 per cent of the area of any cross-section.

The implications of (i) are obvious, especially in relation to arch dam design.

Theoretically it can be argued with regard to (ii), and with reason, that true uplift can never be exerted over 100 per cent of the area A of any cross-section, but only over the interstitial voids—only a relatively small percentage of A—assuming they all can connect up directly or indirectly with the dam face.

However, in practice, there are two explanations used to justify the 100 per cent area assumption, each requiring that the full uplift area is only achieved when many parallel adjacent sections act as a unit, i.e. that depth is required ; in the one case, however, considering the colloidal magnitude of the cement constituents, the depth is so infinitesimal as to constitute virtually a normal section ; in the other case, allowing for the presence of aggregate in the sections, the depth required before 100 per cent of bare area is exposed to cumulative uplift forces must be a measurable amount (e.g. silica sand may set a minimum limit to the depth over which 100 per cent of penetrability is achieved).

To assume that (ii) has no validity in considering stability, since it would contravene the " no tension " criterion, does not seem to make sense. Moreover, the stabilising of the internal hydraulic forces set up in the pores of the dam between two close parallel sections can be achieved by a very small amount of cohesion. Real uplift would only prove formidable in fact if it occurred solely under the foundation base, and no porosity existed to counter it at any and every section.

It would seem, therefore, that this aspect of design requires modifying, though many sound devices are adopted to ensure a rapid fall in pressure immediately downstream of the upstream face and so flatten the remainder of the hydraulic gradient.

It might be added that once percolation has been achieved, a dam never dries out completely with a seasonal lowering of the water level. The consequence is that a rise in level relatively quickly brings about a resumption of the normal internal conditions.

Nothing appears to arise from a study of existing gravity dams, including " high dams," to negative the suggestion that more economic sections could be adopted. The tendency to cracking at the base of high dams is solely due to local stress concentration arising from the abrupt change in section from the ground mass to the dam, which sound design can always mitigate. In these days of rising costs, this points a way to further economy in construction, additional to the recent expedients of altering the constituents in the concrete by addition of fly ash, &c. The resulting design might well put concrete gravity dams on a more directly competitive basis with earth and rockfill dams.

As a further matter of interest, while uplift pressures on given sections have been measured directly in many dams, especially in the U.S.A., showing considerable reduction in the hydraulic gradient, the difficulties of making reliable measurements from the bore-holes are such that even with the most meticulous care, it is inevitable that excess pressures are recorded, owing to the difficulty of cutting off all infiltration water from the portions of the bore-holes above ; the only method of obtaining closely accurate results is probably by using some form of built-in piezometer with polythene or similar tubing attached and carried to the exterior for visual measurement. Possibly this has already been done, as in the case of earth dams.

In conclusion, a further object of this letter is to draw attention to the complete ignoring of the hydraulic internal pressures set up in arch dams, which must exist if the conclusions adopted for gravity dams are correct, and therefore should add their quota in due course of time to the internal arch stresses, countered, it is true, on the horizontal plane by the equal and opposite stresses engendered.

H. F. WILMOT,
B.A., B.A.I., A.M.I.C.E.

Kew, Surrey,
April 8, 1958.

Book Reviews

Ten-Division Influence Lines for Continuous Beams. By Dr.-Ing. G. ANGER, translated from the German by C. J. Hyman. Constable and Co., Ltd., 10, Orange Street, London, W.C.2. Price 47s. 6d.

IN the first part of the book Clapeyron's equation is developed in a general form. There are then set down in tabular form (for a great number of loading conditions) the values of that part of the equation which depends on the loading condition and span lengths, thus enabling the simultaneous equations for continuous beams of any number of spans to be set up quickly. In a similar manner it tabulates equations by which support moments may be calculated for the critical loading condition without having to investigate them for every case of loading. It is perhaps a pity that in these sections the German script is adhered to for a number of variables.

The greater part of the book is devoted to tables giving the values of the bending moment at ten different positions in the length of a beam and for ten different load positions. This is done for two spans, of equal and different lengths, and up to five spans again with span lengths varying. Shears and reactions are also tabulated and critical values for uniformly distributed loads. Since the tables are all calculated for beams of equal inertia a short section is devoted to the way they may be used when the inertias vary.

This book represents a tremendous amount of work (there are over 200 pages of tables) and will be extremely valuable to anyone who has even only a few cases of continuous beams to solve.

Design in Structural Steel. By J. E. LOTHERS. Longmans Green and Co., Ltd., 6 and 7 Clifford Street, London, W.1. Price 56s.

THE first edition of this book was published in the U.S.A. in 1953, and a British edition has now been introduced. The author is professor of architectural engineering at Oklahoma Institute of Technology. The aim of the book is a " thorough treatment of structural design at the undergraduate level." But this does not coincide with a general undergraduate course in structures, since, as the title makes clear, only steel structures are considered and the primary concern of the book is practical design in steel, rather than the development of structural theory. The subject matter is as follows : definition and analysis of rolled steel beams and girders ; tension and compression members ; simple connections and details ; eccentric connections (riveted and welded) ; eccentrically loaded base plates ; built-up girders ; roof trusses ; and steel bridges. American practice is referred to throughout the book.

Books Received

Aircraft Communications Systems. By J. H. H. Grover. Heywood and Co., Ltd., Ingersoll House, 9, Kingsway, London, W.C.2. Price 22s. 6d.

Handbook on Electric Arc Welding. National Coal Board, Production Department, Hobart House, Grosvenor Place, London, S.W.1. Price 7s.

Inter-Firm Comparison : An Incentive to Productivity. The European Productivity Agency of the Organisation for European Economic Co-operation, 2, rue André-Pascal, Paris, 16e, France. Price 24s.

Instruments, Electronics and Automation

No. III—(*Concluded from page 624, April 25*)

More than 250 British companies and 100 firms from ten overseas countries participated in the Instruments, Electronics and Automation Exhibition which opened at Olympia, London, on April 16 and closed on April 25. A conference was held in conjunction with the exhibition, the main items in the programme being a series of afternoon lectures on thermonuclear developments (Sceptre 3), instrumentation and high-altitude rockets, instruments in forensic science, computers and numerical automation, instruments in the petro-chemical industry and instrumentation in iron and steel. Some of the exhibits of interest to engineers are described here.

MULLARD, LTD.

A NEW system of sequence switching in the automatic control of transfer machines and other mechanisms carrying out sequential operations was demonstrated by Mullard, Ltd., Mullard House, Torrington Place, London W.C.1. The main advantage claimed for this system is the improvement in reliability that results from the use of transistor logic circuits, instead of electro-mechanical relays to perform the required switching operations. In addition the transistors can be switched more rapidly than relays, their life is independent of the number of operations completed, and the power requirement is smaller. In applying transistors to control-switching circuits, the logic elements of the digital computer are used as follows: "and," "or" and "not" with "memory," "delay" and "counter" as ancillaries. With these elements, a control system to meet any requirements can be devised. Any logic element that is "and" for one phase of signal is "or" for the other phase. This fact, coupled with the transistor's inherent phase change in the grounded emitter configuration, enables a single circuit to be used for both "and" and "or" elements. Such circuits form the basis units of the Mullard system. The circuit can also be used as an inverter, if necessary, and the two can be combined to form a bi-stable "memory" to replace a latching relay. With the addition of steering diodes the bi-stable becomes the "counter." Up to six input and six output circuits can be connected to one basic unit. The inputs may be derived from push-buttons, photo-cells or any kind of transducer providing the small amount of power needed to switch a transistor. The output circuits give sufficient power to operate inductive loads (such as clutches, motors and large contactors), of up to 36W rating, or non-inductive loads (for example, indicator lamps), up to 50W.

The system makes use of printed circuitry, up to twelve basic logic units being accommodated on one printed board. An appropriate number of boards are mounted, rather in the manner of pages in a book, in a neat metal case to form a compact single piece of equipment. The "book and page" method of mounting gives easy access to any particular group of units. The system is applicable to any form of sequence control problems and installations can be "tailor made" to customers' requirements.

While the system is applicable to any kind of sequence control problem, the particular application chosen for demonstration is the control of a transfer machine performing a sequence of milling and handling operations (Fig. 11). The transfer machine is represented by a specially designed model, in which the "products" are steel balls. A cycle of seven distinct operations is performed automatically, the sequence being controlled by transistor logic circuits, which are the basis of the system. The logic elements feed output circuits using power transistors which, in turn, drive an electric motor and a number of solenoid-operated pneumatic valves which simulate the milling and handling processes. The control system allows the products to be batched for the milling operation, the batch size being preselected and, in the event of the machine failing there is provision for clearing accumulated products from any of the operational stations by means of push-buttons.

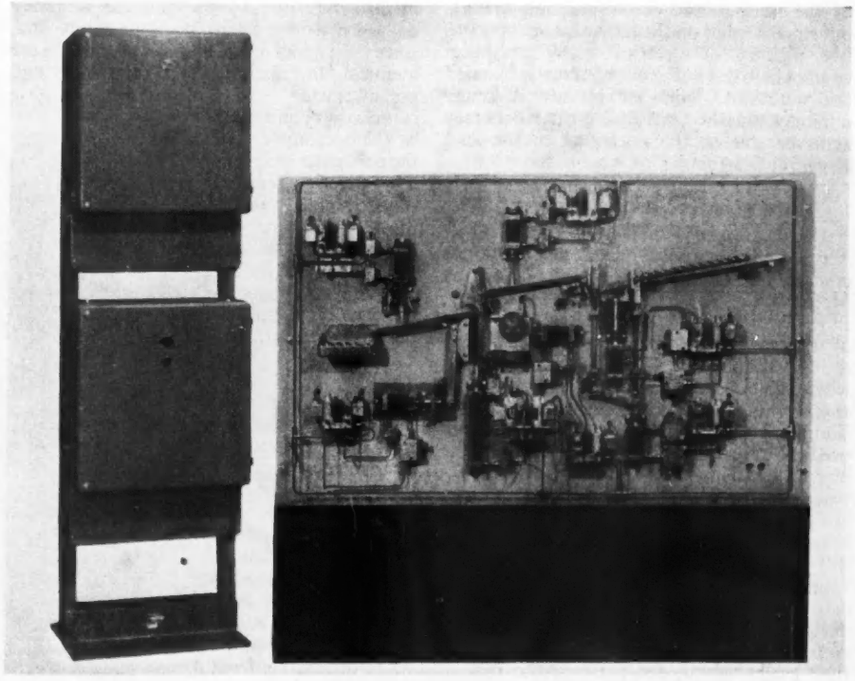


Fig. 11—Model illustrating application of sequence control to a transfer machine performing a number of operations on products represented by steel balls. The sequence of operations is controlled by transistor logic circuits housed in the top case of the rack—Mullard

This company also showed a high-resolution nuclear magnetic resonance equipment, which is a self-contained system recently developed for high-resolution proton spectography by magnetic resonance. While the chief application of the present equipment will be in chemical research for analysis of the molecular structure of compounds and the identification of particular species, the method also has potential uses in process control operations. Briefly, the spectrometer consists of three main components: first, a large, controlled-temperature Ticonal permanent magnet, in the field of which a spinning specimen is located by a micro-manipulator; secondly, electronic apparatus for sweeping the field through the required range; and thirdly, means of observing and recording graphically the nuclear magnetic resonance spectrum. The nominal field strength of the magnet is 7500 Gauss. Although the equipment is designed primarily for studying proton resonance it can be adapted for work with other nuclei. Important characteristics of the spectrometer are the high degree of uniformity of the magnetic field and high overall stability. A typical field uniformity is of the order of 1 part in 10^7 to 10^8 and the spectrometer is therefore stated to be capable of recording the fine structure of the ethyl-alcohol spectrum, that is to say, the CH_3 triplet and the CH_2 quadruplet are fully resolved. Operation of the equipment is based on the Purcell absorption technique, using a single coil. This allows the probe used for introducing the specimen into the field to be of very simple design, and consequently affords great flexibility in varying the temperature of the specimen. The r.f., l.f. equipment and power supplies are housed in a separate console, with the controls, display unit, and potentiometric recorder arranged for a seated operator.

Another new product shown on this stand is the "L.326" dual tank ultrasonic cleaning unit, designed for batch-processing of small components and piece parts such as instrument mechanisms, jewellery mounts, rings and watch parts. It is intended particularly for situations requiring speedy and efficient cleaning on a production scale, but where throughputs are not large enough to justify automatic plant integrated with a conveyor system.

The equipment consists of a compact, bench-standing base housing two 40 kc/s barium titanate transducers, and the two cleaning tanks of "Pyrex" glass or stainless steel. Each tank is of 1 litre capacity and provides a cleaning area approximately 4in diameter and 6in deep. Ultrasonic power is provided

by a separate generator and may be applied to either transducer at will by means of a switch located on the unit.

The operating frequency of 40 kc/s has been chosen to give the unit a wide range of applications ; at this frequency both cavitation effects and high forward beam pressures occur in the cleaning fluid, so that most forms of contamination likely to be encountered are stated to be attacked effectively.

Its dual tanks make the " L.326 " advantageous for applications involving two different cleaning techniques and for two-stage processing using " coarse " and " fine " cleaning agents.

The drive generator (a new type " L.235 " designed specifically for use with the unit), provides a pulsed output of 250W peak. The output is modulated at mains frequency, rectifiers and smoothing components are thus eliminated and the size and the cost of the generator are reduced accordingly. Furthermore, since the barium titanate transducers are effectively " rested " during the negative half-cycles of the mains voltage a higher peak level of drive may be applied to them than would be possible using a c.w. output.

Demonstrations were also given of a new high-precision measuring system suitable for machine tool control. The system embodies the principles and basic accuracies of the normal lead screw and nut system, but since it relies on the inductive or capacitative pick-up of electrical signals physical contact between nut and lead-screw is avoided and wear and friction eliminated. A longer nut may thus be used and greater accuracy achieved due to the averaging of the lead screw pitch errors.

Metropolitan-Vickers Electrical Company, Ltd.

A general-purpose electronic analogue computer was among the exhibits shown by Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, 17. One of the main uses of this computer is in the general solution of differential equations where time is the independent variable. In engineering it has a more important use as a simulator. The voltages on the machine are used to represent the parameters of the physical system, for example, torque, displacement pressure and, since the amplifiers are continuously drift-corrected, the relation between time and the machine and time in the physical system may be a unity ratio. Using the analogue computer the engineer can simulate equipment as soon as it is designed. Tests can be carried out with the computer, and since all the parameters are then easily varied, the performance can be forecast quite accurately and modifications made before manufacture of the equipment is started. Typical examples of its use are in the design of motor-car suspensions and servo-mechanisms.

Briefly, the machine (Fig. 13) consists of a cubicle containing ten operational amplifiers, ten function units and ten potentiometer units ; a power unit, and a display unit. The size and scope of the computer can be increased as desired by the addition of extra amplifier cubicles with their necessary power units.

The amplifiers are continuously drift-corrected and are unique in that they produce in addition to the normal anti-phase output, an output which is in-phase and also continuously drift-corrected. This characteristic eliminates the necessity to use amplifiers merely as sign changers, and accordingly the set-up can be made in a simple and logical manner. The method of setting up a problem on the machine is by plug-in resistors

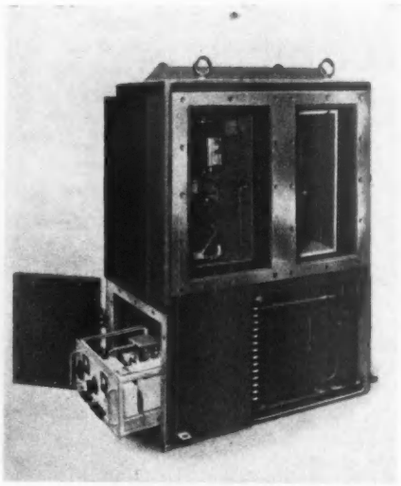


Fig. 12—Vapour phase chromatograph—Metropolitan-Vickers

and capacitors on individual amplifiers, and interconnection is by means of patch-cords, thus ensuring maximum flexibility and simplicity.

In the cubicle all power connections are made at the rear by inserting the amplifier or potentiometer unit from the front and, since all twenty positions in the cubicle are identical, the distribution of amplifiers and potentiometer units can easily be arranged by the operator to suit the particular problem. The function unit is plugged on to the front of the amplifier. The resistors and capacitors, mounted on the unique stackable component carriers, are inserted into the function unit to make the amplifier perform the desired function. On any amplifier the function unit can provide up to nine inputs ; any desired configuration is easily obtainable and the layout is clearly labelled and colour coded. When the desired function has been set up it can be recorded in pencil on the white detachable front plate. This front plate covers the components while clearly indicating the set-up and allowing changes to be made without any disturbance of the interconnecting patch-cords. The input, output, and initial conditions sockets, also the overload indicator, are mounted on the small panel on the front of the function unit and are clearly labelled and colour coded. Each potentiometer unit provides two high-accuracy, ten-turn potentiometers for amplitude scaling ; inside the unit adequate space is available to house special units or networks. The machine can be used for continuous operation or at any of the five repetition rates of from one-half to ten seconds. The mode of operation is selected on the display unit where the output is displayed on a two-beam long-persistence cathode ray tube. A complete range of non-linear elements is available ; all the elements are interchangeable with the standard units and can be inserted in the standard cubicle.

The company also showed a vapour phase chromatograph (Fig. 12) for continuous analysis of samples from a refinery gas stream. Samples are automatically admitted to the chromatograph by a timer-operated gas handling system, and the analytical data are presented at the control room in the form of electrical impulses, which can be used to indicate the composition of the gas stream.

English Electric Company, Ltd.

An automatic programming equipment based on the well-established Post Office type of uniselectors for sequence control was shown by The English Electric Company, Ltd., Marconi House, Strand, London, W.C.2. This equipment has been developed from the original B.I.S.R.A. translator scheme for the control of hot reversing rolling mills and has been devised and built at the company's control and electronics department at Kidsgrove, Staffordshire. To provide adequate interpretation of the scheme, this department has also built a one-eighth scale working model of a 20in merchant mill which is representative of the first installation of this equipment in the United Kingdom. The model performs the essential functions associated with this kind of rolling mill, including the automatic setting of screw-downs, the selection of gate by manipulator and the speed control of mill and table rollers in forward and reverse directions. A steel bar, though not being rolled, is passed to and fro through the mill according to a pre-set programme which is wired-in to the programmer equipment. Fourteen of these programmes are available for demonstration, but the equipment is capable of storing information for fifty such programmes, all of which may require up to fifteen passes each.

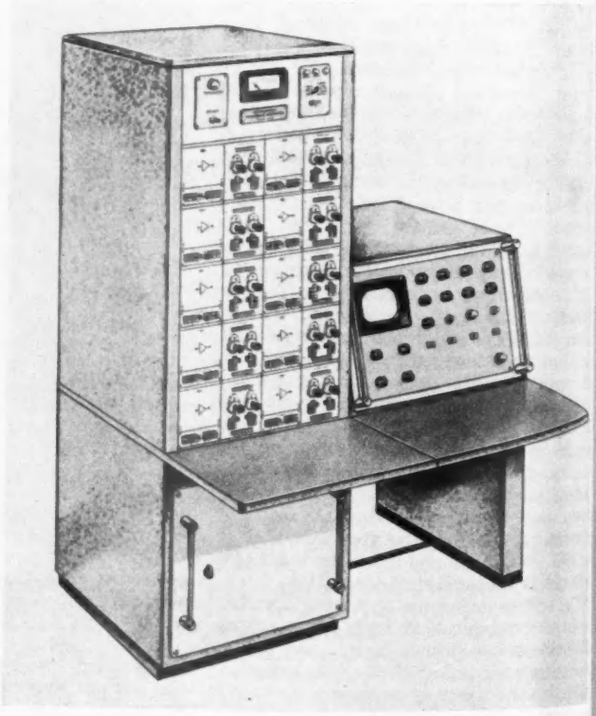


Fig. 13—Analogue computer containing ten operational amplifiers, ten function units, ten potentiometric units, power pack and display panel—Metropolitan-Vickers

In the demonstration the operator sets a combination of switches in terms of the size of the ingoing piece and the required size of the outgoing piece. The programme, thus initiated, then progresses automatically, each sequence being controlled by the bar passing through limiting devices. Alternatively, with this equipment each pass can be controlled individually by the operator at the control desk. The function of manipulator control, although representative, is not true to the full-scale installation, as in practice this has been an over-riding manual control, so that the operator can correct such things as piece-binding and fish-tailing, &c. The exhibit included a plug-board on which temporary or experimental programmes could be arranged. In practice, this facility is used for extra programmes or trial programmes prior to their being wired-in permanently to the equipment. The model is built in to a table approximately 10ft by 4ft by 4ft the base of which contains some of the range of standard magnetic amplifiers developed by English Electric particularly for control schemes of this sort. The amplifiers are used to drive the motors associated with the model and are the same as those used in full-scale installations. The automatic programming equipment demonstrated in conjunction with the model rolling mill is readily adaptable to other forms of process control where automatic sequencing would help to speed-up production, produce more uniform products and reduce operator fatigue.

Marconi Instruments, Ltd.

Two forms of transportable X-ray equipment for industrial radiography, both suitable for field, workshop or laboratory use, were among the exhibits shown by Marconi Instruments, Ltd., St. Albans, Herts. Both equipments are dust-proofed and spray-proofed and are built to withstand the day-to-day handling that may be expected in factory or dockyard usage.

One of these sets, the 175kVp "TF 1593" equipment, is illustrated in Fig. 14. It consists of two transportable units, connected during operation by a low-tension cable; various accessories in a metal case are available optionally. The h.t. tube unit is basically arranged for the new 360 deg. circumferential techniques to provide simultaneous multi-radiographs of objects arranged in a circle, or single radiographs of an entire circumferential weld, from inside vessels, pipes, &c. With a simple set of components it can be quickly adapted to cater for normal 40 deg. cone beam techniques. The necessary alternative styles of X-ray inserts are available and can be supplied as selected to suit the techniques desired. The rating of the basic set is 5mA at 175kVp (continuous) or up to 8mA for fifteen minutes alternating with fifteen minute cooling intervals. Use of an optional cooling fan will permit somewhat higher ratings. The equipment is quickly and safely readjusted from the control panel for use on any 50 c/s, single-phase, a.c. mains within the range 100V to 415V. Under average conditions the complete equipment can be set up and ready for operation within ten minutes of arrival on site.

The dust-proof and moisture-proofed cylindrical unit contains two h.t. transformers (each producing half the kilovoltage with one end of each winding earthed); the tube filament transformer, and the necessary insulating oil. The diameter is reduced to form a waist 8½in (22·3cm) outside diameter, about the area where the X-ray beam emerges. The inherent filtration is 3·5mm of aluminium. Encircling this waist are two stainless steel groove tracks to which can be attached the external field-defining protective shields, also a portal and adaptor for beam direction. Filters and field defining diaphragms are available. For a 360 deg. beam insert, circular handles may be used, while for insertion of the unit into pressure vessels or pipes or to reduce its overall size for transportation, the handles are easily detachable and ring bolts facilitate the use of hoisting tackle. For use with a 40 deg. beam insert, square rubber-sheathed handles are provided to permit the beam to be directed up or down or to left or right without fear of the unit rolling out of position. The 360 deg. insert has an effective focal spot size of 1·5 square millimetres and will provide, about the long axis of the cylinder, a 360 deg. band of radiation 24 deg. wide. At an f.f.d of 10in this will fill a 4½in wide strip of film. The 40 deg. insert has an effective focal spot size of 1·5 square millimetres or 2·3 square millimetres and provides a 40 deg. cone of radiation at right angles to the long axis of the cylinder, which will fill a 17in by 14in film at an f.f.d of 28in.

Protection against scattered radiation is

Fig. 14—Transportable, 175kVp industrial X-ray equipment "TF 1593"—Marconi Instruments

built-in and the interconnecting cables provided are of sufficient length for the operator to control the equipment from a safe distance. Mounted at one end of the h.t. unit cylinder is a keyed socket to accommodate the cable plug; a second socket supplies 12V for the illuminating beam director or an inspection lamp. A third socket permits the interconnection of an orange warning light or sign "Danger X-Rays On," which is illuminated only when the tube is energised, conforming to the recommendations of B.S.S. ref. CX(PSM)2532/1957 "Precautions Against Radiation Hazard in Industrial Radiography." Sockets are also provided for the connection of oil hoses. A pressure operated safety relay is mounted within and is interlocked with the exposure contactor in the controller.

Being a transportable equipment the control unit is suitable for connection to any 50 c/s, single-phase supply between 100V and 415V a.c. It is assembled in a sheet-steel fabricated box, designed to be spray proof and dust proof even without the removable lid in position. Coarse and fine line-adjust tap switches, together with the input fuses are placed under a hinged cover which operates an interlock switch when closed, thus preventing the generation of X-rays with the cover open, and protecting the h.t. unit from damage caused by alteration to these controls with the h.t. transformer energised. Further protection to the control unit and the h.t. unit is given by the inclusion of a voltage sensitive relay whose contacts will break and so prevent the line contactor being closed should the incoming supply be more than 50V above the value selected by the coarse and fine switches. Should the supply voltage be below the settings, this condition would be indicated on a meter.

When not in use all plugs and sockets are protected by captive screw-on covers. All meters are protected by being mounted below the top panel level and covered by sealed windows of transparent plastic. Four indicating meters are built-in. They are: (1) An hours counter, which shows the total of the X-ray tube filament life. (2) A kilovolt meter with a pre-reading range of from 40kV to 180kV under preselected load conditions. This meter is also used to monitor the line input volts when the Check button is pressed. Indication that the equipment is correctly adjusted being given by a blue reference line on the meter scale (3) A milliampere meter with a range of from 0mA to 15mA which indicates actual tube load during exposure. (4) An exposure timer, operated by a synchronous motor and having a range of from 0 to twenty-five minutes, is arranged to terminate the exposure at zero. A red pointer shows the original time selected and an automatic reset system permits repeated exposures to be made without further adjustment to the timer.

A four-position milliampere selector gives the range 1·5mA to 12mA while a fine milliampere control is brought into circuit on the first step of this range, giving a continuously variable adjustment from 1·5mA to 5mA. Automatic load compensation is provided so that as the milliampere is increased the kilovolt indicated on the kilovolt meter will decrease, and vice versa, and the kilovolt control can be readjusted for the desired potential. An interlock circuit prevents the use of the higher milliampere ranges without an oil cooler, thereby protecting the tube from damage due to overheating. Coarse and fine kilovolt controls cover the full range from 40kVp to 180kVp in steps of 2kV. Micro-switches, incorporated with both these controls, prevent them from being used with the h.t. transformer energised.

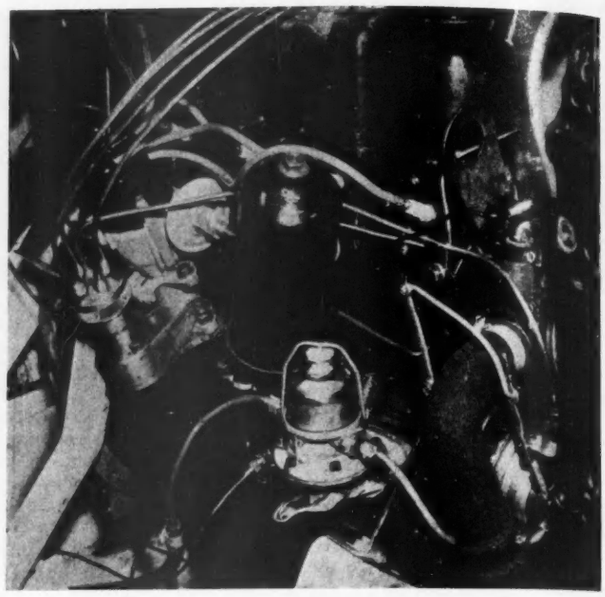
Pilot lamps, to show when the equipment is switched on and when X-rays are being generated, are situated immediately above the relevant controls on the front panel. Press-button type switches are included for line "On" (orange), "Off" (green), and "Check" (blue); for exposure "On" (red) and "Stop" (green); the latter to interrupt an exposure if required.

By removing four fixing bolts (the key for which is clipped in the lid) the panel can be lifted by the rails, for access to all components below; everything is secured to this panel to facilitate withdrawal and inspection. This unit is located and secured internally on resilient anti-shock mountings. It is built up of several sub-assemblies, each of which can be dismantled from the main chassis for servicing.

Combustion Supervision.—The cadmium sulphide photo-electric cells that have recently become available (see page 479, March 28 last) are employed in a series of low-cost combustion monitors announced by Photoelectronics (M.O.M.), Ltd. They comprise a smoke alarm and a smoke density indicator, giving qualitative and quantitative indication of the smoke density in chimneys up to very large sizes, and an automatic oil burner control employing the cell as a flame failure detector.

Positive Petrol Distribution

A low-pressure metering pump has been provided with a distributor and applied to the injection of fuel on a petrol engine. The detail design is noteworthy for the interesting exploitation of organic materials. Development work is seen here with a pump on the nose of the camshaft and a distributor geared to the ignition distributor.



THE metering pumps that are used on many diesel engines and on petrol engines requiring very high performance or environment immunity have for long been regarded as being examples of extreme precision engineering and appropriately costly. A pump which is expected to be substantially cheaper in production quantities, and satisfactory for service under the less onerous conditions of ambient temperature and delivery pressure, has been evolved on the Continent and subjected by Lexington Products, Ltd., to petrol engine running and further development. The distinctive feature of the pump is the sealing of the piston and cylinder by a resilient ring, which, being elastic, acts also as a return spring for the piston. This can be followed in Fig. 1, which

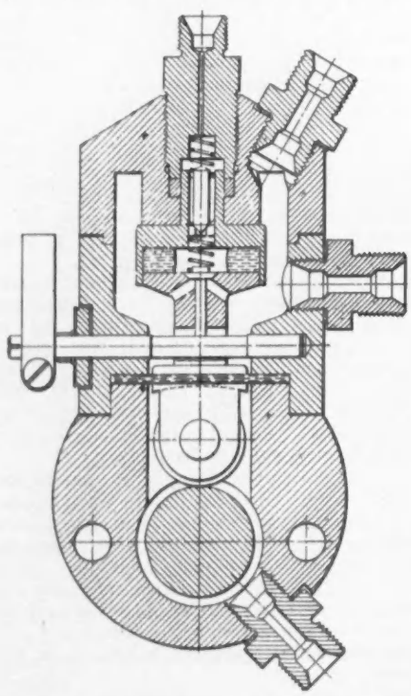


Fig. 1—Section through metering pump ; the control eccentric is set for full delivery and the inlet valve is just closed

shows an early form of pump built for development work on single-cylinder engines.

The method of regulation is unusual and deserves description ; the inlet valve is in the head of the piston, and is closed by a spring. A passage through the piston rod admits a control shaft journalled in the housing : a cam on this shaft holds the valve open until the upward movement of the piston allows the valve to seat. Thus only from this point on is the delivery stroke effective, and by rotating the cam the delivery can be varied. The timing of injection commencement will advance with increasing quantity, delivery ending always at the peak of the driving

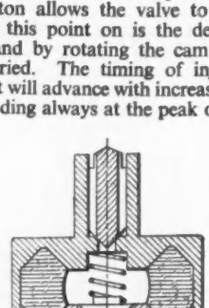


Fig. 2—Modified form of pumping element

cam : there is a spring-loaded delivery valve. These details must be studied in the knowledge that a cam with a very rapid rise—10 deg. on the camshaft, corresponding to 20 deg. crank angle on a four-stroke—is used : the cam is symmetrical, suiting the pump for rotation in either direction. This profile, which actually involves concave cam faces, is practical in view of the relatively low delivery pressures required : it will be seen that the fuel is confined to the pump proper, the driving camshaft having the benefit of engine lubricating oil. The cam lift is of the order of 0·012in to 0·015in, depending on the size of the engine cylinder. The short delivery period results in the timing of the pump being important, but this is a variable at the designer's control.

In the course of testing on the road, including much sustained high speed running and the use of high-aromatic fuel, it was found that the synthetic rubber ring had a limited life. The adverse effect of aromatics in the fuel led to a change in the material to the "F.R. (fuel resistant) 75" grade of George Angus and Co., Ltd. A tendency for the faces in contact with the piston and cylinder to become "burnt" was eliminated by changing to a ring section designed to give a maximum strain energy for a minimum shear stress at the surface of the material: the section adopted is shown in Fig. 2.

For multi-cylinder engines a distributor is employed, tests on the pump having shown that its response is adequately rapid for over 10,000 deliveries per minute. The present form of fuel distributor is shown in Fig. 3 : the pump delivers to the central bore facing the rotor, and the passage in the head of the rotor passes in the firing order over each of the ports leading to the nozzles.

The ports are bored in a loose plate, restrained against rotation by a lug extended into a recess in the distributor casing, the plate being faced with p.t.f.e. compound by Glacier Metal Company, Ltd. The plate is held in contact with the rotor by the compressive stress in the synthetic rubber rings sealing each of the fuel passages. While the distributor must be in the correct phase with the camshaft, the timing is not critical compared to that of the pump : such small adjustments as are made to the ignition distributor would have no effect upon the former. A feature of the design that will be noted is that the perimeter of the rotor-seal joint exposed to fuel pressure is kept to a minimum, although an open channel in the rotor head would be more simply made. The rotor is carried in bearings faced with p.t.f.e., again provided by Glacier : earlier distributors used for test bed work ran on a pair of ball bearings.

The injector shown in Fig. 3A is one evolved for use with this equipment, the initial running of the pump having been with Bosch injectors. It will be seen that the nozzle, like the pump, employs the principle of using a plastics ring both as a seal and as a spring. Only the one ring above the needle was originally used, but this rendered the variation of opening pressures with setting of the screwed cap undesirably abrupt, and the additional ring below the flange counteracts this.

The pump is so installed that fuel is delivered continuously to the lower chamber, the excess returning to the fuel tank ; this serves to cool the pump and also reduces the possibility

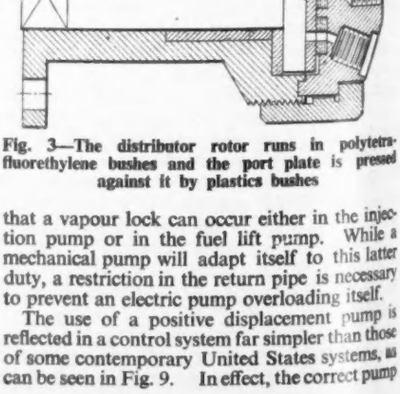


Fig. 3—The distributor rotor runs in polytetrafluorethylene bushes and the port plate is pressed against it by plastics bushes

that a vapour lock can occur either in the injection pump or in the fuel lift pump. While a mechanical pump will adapt itself to this latter duty, a restriction in the return pipe is necessary to prevent an electric pump overloading itself.

The use of a positive displacement pump is reflected in a control system far simpler than those of some contemporary United States systems, as can be seen in Fig. 9. In effect, the correct pump

setting, assuming adequate atomisation, depends only upon volumetric efficiency. The principal factor governing this is of course manifold pressure, and a conventional medium-speed engine with a carburetter has been found to exhibit a relation between manifold pressure and fuel consumption per revolution almost independent of speed. While it is clear that this is not an ideal mode of operation, it has been used in the initial proving of the equipment with satisfactory results.

While a fuel-injection engine is obviously free from the adverse effects of petrol condensing on or evaporating from the manifold walls as the manifold pressure alters, the need to give the driver a pleasing response to sudden throttle

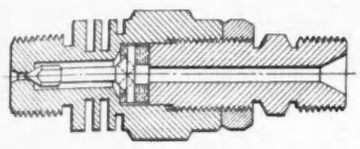


Fig. 3A—The injector, like the pump, uses plastic rings both as seals and springs

movements has led to elaboration of the control mechanism. It can be seen that, in addition to the spring-loaded air servo-cylinder *G* sensing manifold pressure, there is a diaphragm servo motor *N*, of the pattern associated with advance/retard mechanisms, connected to the ignition advance tapping. Thus, even if opening the throttle does not cause a large enough change in manifold pressure to overcome the friction of the main servo, the increase in pressure near the throttle butterfly will disturb the linkage. In the form currently used, there is more than one tapping point near the throttle, and these points *U*, *T* are joined, past restrictors *E*, *F* to the main pressure tapping. This latter interconnection has the effect that, for part throttle openings, the pressure in the main servo ram is somewhat less than true manifold pressure, but at full throttle this difference disappears ; thus the control system can be set to run the engine at its most economical mixture strength except when the throttle is fully open, and at maximum power mixture strength then. While the most lucid demonstration of the effectiveness of the system would be a set of fuel consumption characteristics on bases of torque and speed, these are not available since the programme was directed to the development of the injection equipment rather than of one particular engine ; in fact, the principal difficulty with the control system proved to be securing satisfactory response in the unsteady conditions that are inflicted upon automotive engines. It can be taken for granted that if the system were to be applied to an existing engine, a fresh programme of development in respect of timing, air flow, cooling, and so forth, would be necessary to achieve optimum results. It has also to be envisaged that there would be a need for correction for variation of both barometric pressure and ambient temperature, although at this stage it is not possible to predict how sensitive engines will prove to be to these effects. It is anticipated that the source of such corrections would be a sealed capsule acting as a spring in the control mechanism ; if the gas in the capsule is at a pressure sufficiently far from atmospheric, any desired ratio between pressure sensitivity and temperature sensitivity can be obtained.

Development Running

Engine running commenced on the type of unit having most to gain from fuel injection, the loop-scavenge two-stroke. A single-cylinder Villiers engine was modified to a positive-feed, total-loss lubrication system and converted to direct injection : apart from the expected improvements in fuel economy away from the design condition, the useful power now extended to markedly higher speeds, the engine having, in fact, been run up to 3000 r.p.m. However, since the application of direct injection involves consideration of the most fundamental design details of the engine, it was decided to continue pump development work on manifold-injection systems, which have application to the great bulk of engines manufactured in this country : two-stroke running is being done now by engine manufacturers and, we are advised, showing clearly how many of the problems of these very difficult engines were due to the aspiration of mixture.

A particularly interesting engine which was used to develop a single-cylinder installation was the A.J.S. " 7R " racing engine. On such an engine as this volumetric efficiency is, of course, highly dependent upon tuning of the induction and exhaust tracts, and the carburation problem is accentuated by the severe changes in the gas velocity, which may be expected to go negative at certain parts of the cycle at some speeds. (By the most elementary theory, when the pulse corresponding to exhaust valve opening has time to traverse the exhaust pipe four times instead of twice while the exhaust valve is open.) Thus, it is easily credited that pump timing proved to be highly critical: the optimum timing was 10 deg. before b.d.c. on the induction stroke, when the exhaust valve had closed. The improvement in brake mean effective pressure was most pronounced at relatively low speeds, the carburetter in this case being designed predominantly for peak power. The brake mean effective pressure at peak speed (190 lb per square inch at 7600 r.p.m.) showed, in fact, a decrease of about 3 per cent, but this was attributed to the fact that the length of the induction pipe had to be altered to accept the nozzle. The improvement in outputs less than peak is particularly important in view of the fact that the " 7R," in common with other British machines, uses only a four-speed gearbox. When a carburetter is used, it may be necessary to slip the clutch even in first gear, on a circuit with slow corners, to reach the engine speeds at which the induction system and exhaust pipe are attuned, i.e. to get on to the megaphone. The fuel injection engine does not misfire when flow reversal through the carburettor occurs, so that, with the same gear ratios, it can accelerate the machine without recourse to partial disengagement of the clutch. This means, of course, that the skill needed to handle the machine is reduced ; however, it was considered that the skill of the rider was not the limiting factor in the performance of the " 7R," and injection has not been adopted for the machine.

The distributor system for multi-cylinder engines has been developed on a 1390 c.c. Hillman " Minx " engine. In so far as an individual engine can be taken as representative, this is probably an example giving a fair illustration of the comparison between carburation and injection on an engine designed and developed for the one system : it is not a highly rated engine, this example having a brake mean effective pressure of 110 lb per square inch at 2400 r.p.m. and an output of 40 b.h.p. at 4400 r.p.m., and therefore there should have been no conspicuous sacrifice of the part load characteristics of the carburetter in favour of peak power.

Running with fuel injection commenced with Bosch injectors fitted into the original manifold. Fig. 7 shows that an improvement in efficiency resulted

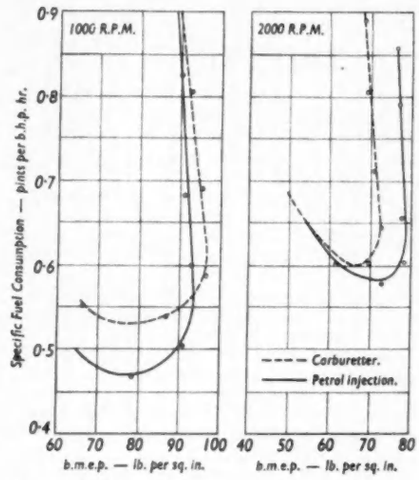


Fig. 4—Constant speed consumption curves at quarter throttle

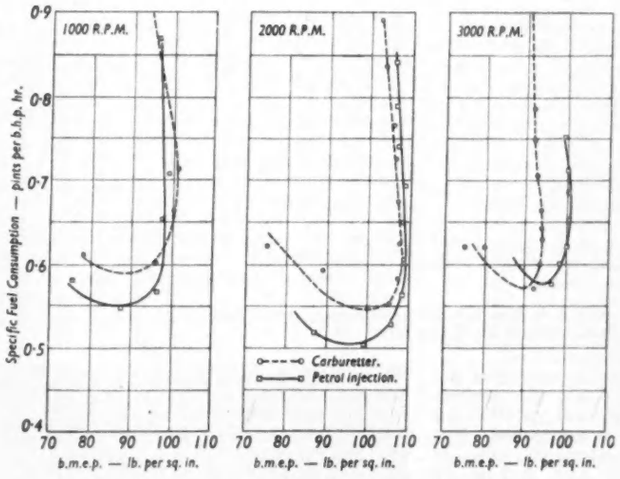


Fig. 5—Constant speed consumption curves at half throttle

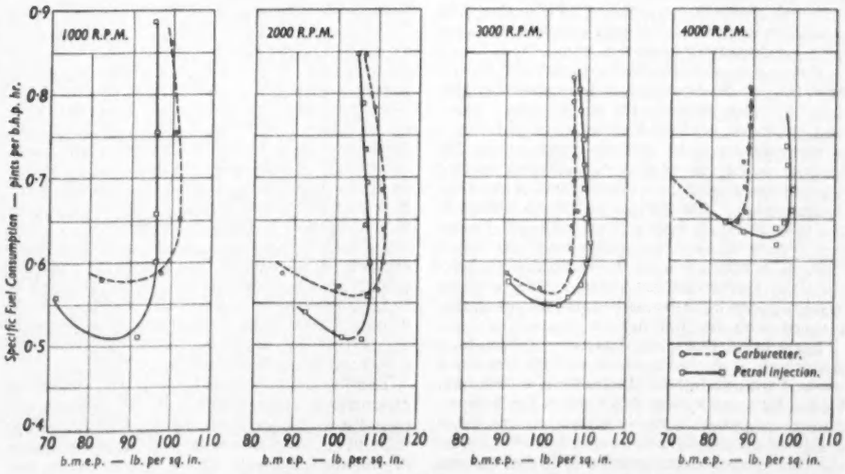


Fig. 6—Constant speed consumption curves at three-quarter throttle

at low engine speeds, due to the more consistent petrol distribution attained, but did not persist above 2000 r.p.m., suggesting that the air distribution at high speeds was uneven. An entirely new manifold, devoid of a hot spot, and with the duct for each cylinder as similar as possible, was therefore constructed and fitted, with the effect not only of increasing the torque, but also of securing a consistent improvement in fuel consumption. With the new manifold and Lexington injectors, a full calibration of the engine has been carried out, and the fish-hook

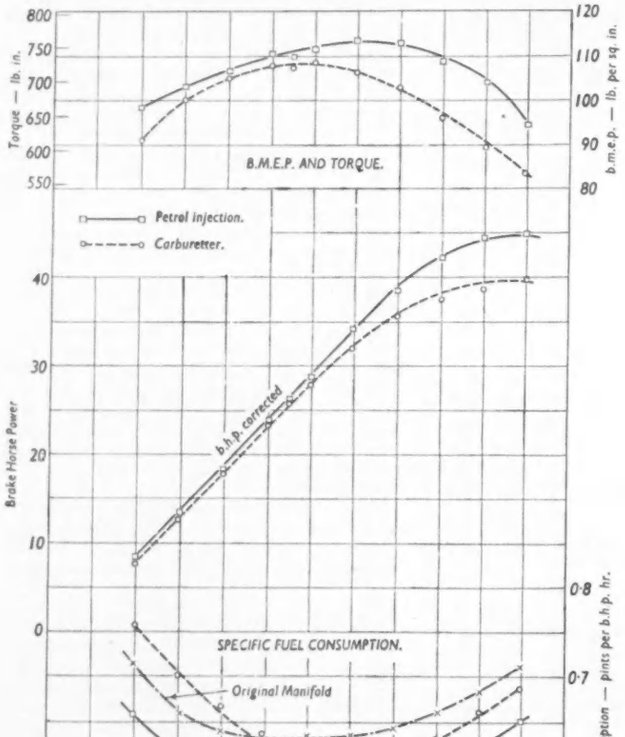


Fig. 7—Full throttle performance ; ignition adjusted to optimum torque. Fuel pump delivery fixed, injection at 75 deg. after T.D.C.

curves are reproduced here for carburetted and injection engines (Figs. 4, 5 and 6). Mixture strength characteristics at full throttle for the injection engine were not measured, since heat rates much in excess of those of the original design would have had to be imposed on the engine. It should be noted that the single curve for the full throttle case was obtained for a fixed pump setting, and represents a performance that could be obtained with a rudimentary control system.

The engine was installed in a car, a " Minx " MkVIII, for development of the control system and, as was related above, it was found that the most difficult feature to obtain was a pleasing response to control inputs : the behaviour when the engine was allowed to find equilibrium running conditions was at no time unacceptable. The control system at present in use is large for its task and unnecessarily heavy, but it can be seen to respond to very small changes in speed and load. Designs have been prepared for production control systems which would appear but as small components, probably integral with the pump.

The injector of Fig. 3A has not yet been fully developed and the control system has been evolved with an interim nozzle using a steel ball, loaded by a coil spring, as a valve. Fig. 9 shows that, even as with a heavy oil engine, the detail design of the nozzle has a deep-seated effect upon the fuel system characteristics : it can be seen that with the Bosch nozzles originally used, it was necessary to reduce the pump setting 6 deg. as the speed rose from 800 to 4000 r.p.m. at a constant throttle setting. Moreover, the travel needed to pass from full throttle to road load torque was increasing rather than reducing through this speed range, implying that the response to the control was markedly non-linear. The first pattern ball-valve nozzle rendered the control setting much less sensitive to speed and more sensitive to torque, although both relations are highly non-linear. These nozzles were also found to impose an excessive pressure rise with increasing engine speed —it will be recalled that the rate of injection of this system is particularly high—and were accordingly modified to have a larger orifice, the spray quality at low speeds being maintained by a heavier spring. The characteristics of the pump with these nozzles are distinctly different : the full throttle pump setting now varies only 2 deg. through the entire speed range, and while the response necessary to accommodate changes of torque is clearly not independent of speed, it is higher at the higher speeds, where more energy is available from, say, a venturi. The apparent non-linearity has been reduced in the actual control system by using a crank, rather than the push-rod illustrated in Fig. 8, to drive the cam. In the case of the " Minx," it has proved possible to close restrictor *D* completely, thus virtually isolating the speed-and boost-sensing servos.

The " Minx " with the basic control system has experienced such extremes of temperature and pressure as can be found in the Alps of Europe without apparent deterioration of its performance. A manual over-ride, *Q*, *R*, allows excess fuel to be selected for a cold start : immediately the engine reaches idling speed this can be returned to normal, without regard for the engine temperature.

A brief experience of the experimental car showed us that the system goes far toward overcoming one major deficiency of the commonplace carburetted engines, the absence of an idling governor. Despite the fact that the idling speed was so low as to be obtrusive, the vehicle could be moved away, even in third gear, solely by engagement of the clutch. The behaviour at very low engine speeds also was transformed : the torque remained finite and high as the speed was forced down until finally there was insufficient momentum to complete the next compression stroke. In effect, it was virtually impossible to " lose " the engine : it could only be stalled by overloading it until every power stroke was felt through the transmission. At the opposite extreme, the effect on the performance at high speed was less striking but even more valuable : at any speed not mechanically dangerous, the manifold depression was no more than 1in. The response to the throttle was faultlessly sharp, and there existed no possibility of causing a misfire or hesitation by manipulation of the pedal. At the time, the travel available to the control units did not allow the pump delivery to go down to zero —even when the engine was absorbing power the

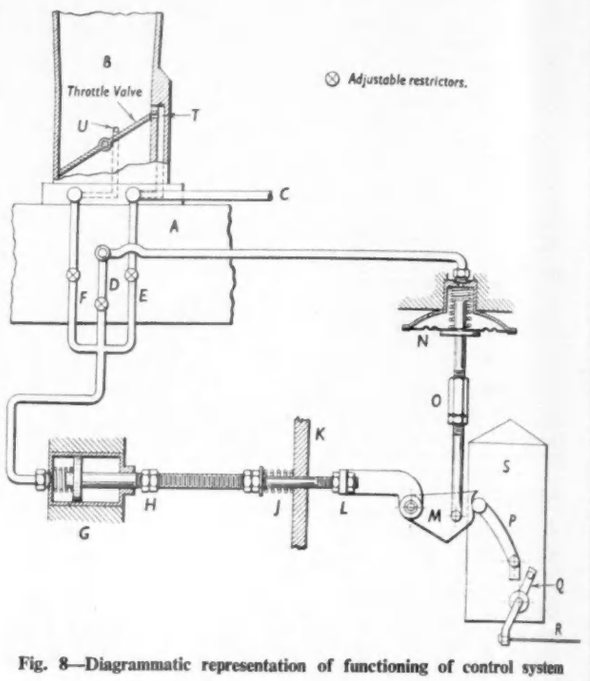


Fig. 8—Diagrammatic representation of functioning of control system

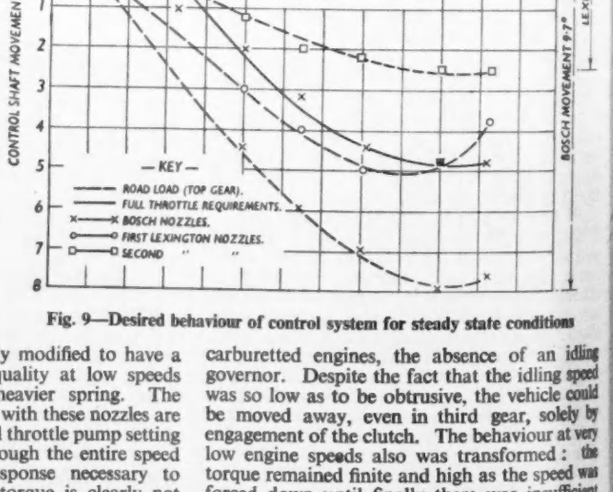


Fig. 9—Desired behaviour of control system for steady state conditions

"Petrometa" showed a finite fuel consumption—so that in this respect the test may not have been representative. Starting of the engine when hot was invariably immediate, even if it had been stopped by stalling it on a large throttle opening.

Equipment on the test bench and in the workshop included pumps with eight-lobe cams: the lift is again much shorter than the dwell, and the resulting complicated form was generated by profile grinding. Such a pump was demonstrated running at 3000 r.p.m., equivalent to 6000 r.p.m. crankshaft speed, and it was shown that one of the Lexington nozzles was capable of handling the entire pump output: the critical speed corresponding to the natural frequency of the needle-spring combination is, in fact, out of reach on conventional fuel injection test gear, even with the eight-lobe cam pump. It is interesting to note that both pump and injector, with their rubber springs affording a measure of damping, are practically noiseless in operation, in sharp contrast to the high-pressure injection systems of compression-ignition engines: certainly the system would not be audible when installed on a poppet-valve engine.

Diesel Engine Developments

WHEN the "Four 99" engine, of F. Perkins, Ltd., Peterborough, was introduced (see page 754, November 22 last), we recorded that the performance of the combustion chamber remained satisfactory at 4000 r.p.m., and that use could be made of this characteristic by fitting variable timing pumps. This development has now been performed, and of the two new ratings now available, one offers 42·3 h.p. at 3600 r.p.m. and 43 h.p. at 4000 r.p.m., gross, for goods and passenger vehicles respectively, with a maximum torque corresponding to 111 lb per square inch, b.m.e.p. (73 lb-ft) at 2250 r.p.m. The other rating is a twelve-hour B.S. 649 output, rather lower than the original agricultural, of 32 h.p. at 3000 r.p.m.; maximum torque is again at 2000 r.p.m., reduced to 60 lb-ft, and 2500 r.p.m. may only be exceeded in approved applications. The automotive engines have a lighter flywheel than the agricultural models, and weigh about 385 lb instead of 456 lb. At this stage consumption figures are not available, even at the nominal agricultural output, and we can do no more than reiterate that the lowest consumption is about 0·41 pint per brake horsepower-hour.

Our previous description of the fuel pump needs elaboration in this context; the variable-stroke pump in its simplest form, as illustrated on page 374, September 14, 1956, has the termination of the injection period fixed at any given speed. This is not well suited to the needs of the engine, which approximate to commencement of injection constant for varying torque. Two different mechanisms are used to obtain the desired variation in timing. One modifies the pressure applied to the variable timing piston by connecting the timing device to transfer pressure past a bleed varying with governor setting; this system is used on mechanically governed pumps. On hydraulically governed pumps, as on the Perkins engine, the cam ring is located in the timing piston (*N* in Fig. 2, *loc. cit.*) by a spring which drives it in the "advance" direction against an abutment on the piston; the increase in the torque imposed with increase in plunger stroke therefore causes the cam ring to be retarded.

At the automotive rating the engine is considered to be suitable for passenger car use, and a number of vehicles have had the 1621 c.c. unit installed. In most cases the original clutch mechanism is mounted on the Perkins flywheel, and the dynamo and other small components are retained. One interesting feature of some of these vehicles is that the "Thermostart," instead of having a very small reservoir to protect the engine from over-temperature if combustion continues after the selector switch is released, draws from a special tank which can be filled with gas oil or any other satisfactory fuel. An enlarged battery is also fitted to encounter the greater starter motor draw.

Conversion kits are available to enable these engines to be installed in a number of vehicles, most of which use as standard petrol engines of higher power. One such completed conversion is illustrated; in common with most of the conversions, no structural alterations are necessary, beyond the drilling of a few holes, but the pipes leading to and from the silencer are changed. Since the engine, unlike earlier Perkins units, does not use a pneumatic governor and is not controlled by a throttle, and has no exhauster, the windscreen wipers are changed from an air motor to electric operation. The battery is also changed, from the normal nine-plate assembly of 45Ah or 57Ah to an eleven-plate, 64Ah unit. Details of the installation that may be of interest are that Bowden cable is used to render the accelerator control immune to engine movement, and that an idling speed adjustment is also provided for use when the engine is cold. The main differences in the operation of the modified vehicle concern the lubrication; the Mark II "Consul" is cleared for mixed-viscosity oils and expected to use the same oil summer and winter, with changes every 5000 miles. The Perkins engine uses fully detergent oil of viscosity 10W below 30 deg. Fah., 30 above 80 deg. Fah., and 20W or 20 in between, and oil changes are required every 2000 miles.

The heavier engine and battery raise the weight by some 2½ cwt, a typical car weighing 2780 lb unladen. This increase, entirely on the front wheels, is accommodated by a change of the coil springs of the front suspension to "Zephyr" components. The installed power is, of course, considerably less than with the 1703 c.c. engine, the gross torque of the small engine being 73 lb-ft against a net maximum of 91 lb-ft at 2300 r.p.m., and the gross power being 43 h.p. at 4000 r.p.m., whereas the original engine had a net output of 59 h.p. at 4400 r.p.m. There is naturally a major change in fuel consumption, particularly on a volumetric basis; the figures offered to us are as follows:—

Average speed	M.p.g. (petrol)	M.p.g. (derv)
30...	32·3	53·7
35...	29·1	48–49
40...	27·0	37·0

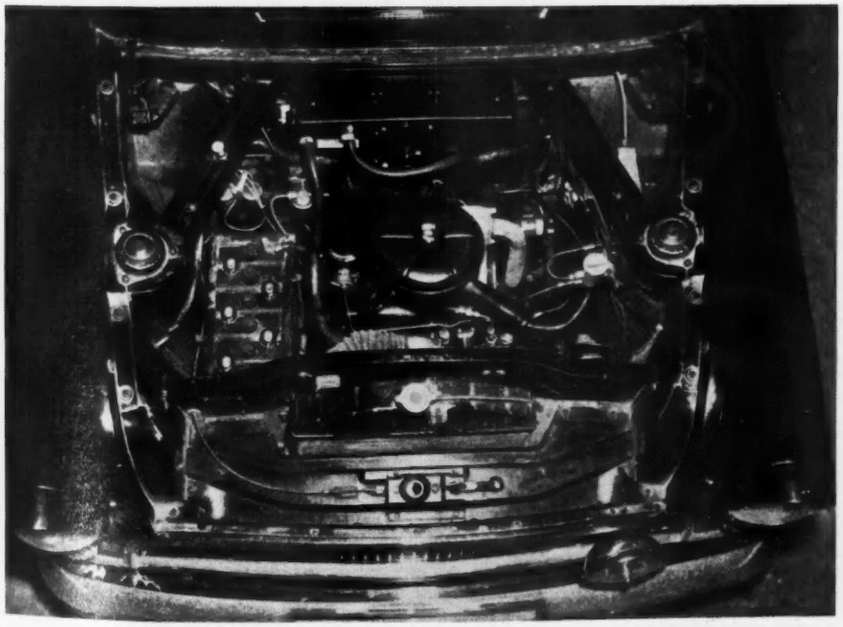
These figures are confirmed by an R.A.C. observed run in which a running average of 34·78 m.p.h. over a 218-mile return journey was achieved at a fuel utilisation of 50·8 m.p.g.

A corresponding test on a Vauxhall "Velox" of the 1955–56 pattern, loaded to almost the same weight and similarly converted, showed a utilisation of 56·6 m.p.g.; this difference may be attributable to the rather higher overall gearing of the older car, which normally has a 2¼-litre engine.

We have been afforded the opportunity to see and drive the "Consul" and various other converted cars and vans. From outside the car the noise is sharper in nature and betrays the compression-ignition engine, but among numerous vehicles being demonstrated we saw smoke only from one engine running at extreme revolutions per minute. The engine is audible to the passengers when idling, as is not normal in the "Consul," and at low speeds is comparatively noisy at part load; at high torque or high speed engine noise is usually slight and never unpleasant. Because any torque up to the maximum can be selected without restraint at any speed, as is not usual on a carburetted engine, a three-speed gearbox gives a perfectly tractable performance; if the engine speed is allowed to fall to an extremely low value, the only protest is a distinct combustion noise at minimum fuel, which would be noticed at about 10 m.p.h. in top gear. The inertia of the engine appears to be high, upward changes being distinctly deliberate, while the accelerator seemed remarkably heavily sprung.

On a Beardmore Mk. 7 taxi, the bonnet panels, which are simply curved, had been heavily damped with an organic adhesive to reduce engine noise, while in forward-control vans the engine was clearly audible whenever combustion was taking place; in all other respects, the engines were free of undesirable characteristics.

The hydraulic all-speed governor of the "D.P.A." pump is, however, open to criticism. The provision of a fast idle selector suggests that the governor lacks effectiveness at low speeds, and in fact it was found that if idle was selected from a condition in which the governor had reduced the fuel flow to limit engine speed, the engine would stop. Moreover, only with a very low gear or extremely delicate clutch operation was it possible to start a vehicle without increasing the governor setting. While the governor does, apparently, render it distinctly easier to engage sliding gears when changing down, it seems doubtful whether its presence is justified in passenger cars where the smoothness of driving is prejudiced by the highly non-linear response to accelerator movement. The maximum speed limitation does, however, encourage the performance of racing downward changes, and it also safeguards vehicles fitted with four-speed boxes and remote gear controls against missed changes.



"Four 99" engine installed in "Consul"; notice the enlarged battery and, beyond the radiator, the paper element fuel filter. A "thermostat" and its gravity tank can be seen

SHORTER REPORTS

Blackwall Tunnel Improvement

WORK was inaugurated on the first stage of the London County Council's scheme for the duplication of Blackwall tunnel on April 21. This first stage involves reconstruction of the north approach to the tunnel, to serve both the existing tunnel and the second one which it is planned to build.

The approach will provide for eight lines of traffic on four carriageways, each 20ft wide ; the two centre carriageways will underpass East India Dock Road, the west slip road will cater for traffic leaving the tunnel for the west and the east slip road for traffic entering the tunnel from the east.

A bridge to carry East India Dock Road over the open approach is to be constructed and the excavation for this and for the approaches will involve the demolition of entrance buildings to the tunnel and East India Dock and of part of the existing approach. Other construction will include new roads and the widening of existing roads to link with the approaches, a new entrance to East India Dock, the reconstruction of the dock wall to a new line, a pedestrian subway, access stairs to bus draw-ins on the underpass, an underground pump house, lighting and drainage.

The bridge at East India Dock Road is to be constructed in two spans with reinforced concrete abutments and a concrete encased steel trestle on a heavy reinforced concrete invert slab ; the superstructure consists of steel beams encased in concrete with reinforced concrete deck slab. The construction will be complicated by the necessity to construct in sections in order to deal with East India Dock Road traffic, as only east-bound traffic can be diverted from the site. The phasing of the bridge construction will also be governed by extensive diversions of pipes and mains, which, in addition to large banks of normal telephone and electricity cables includes the main feeders to the London Transport trolley-bus system, two 48in diameter gas mains, a 24in gas main and a 20in water main. All have to be incorporated in the bridge deck and in order to reduce depth over the bridge, two 36in diameter steel pipes are to replace each 48in pipe and are incorporated in a special pipe bay across the centre of the bridge. In addition the main Isle of Dogs sewer has to be diverted to a point where it can pass under the open approach.

Borings indicate standing water at such a level that with normal construction the lower parts of the work would be buoyant and it has been necessary to provide additional weight in the structures to counteract this. The open approach will have a heavy reinforced concrete invert slab with reinforced concrete walls faced with 4in Portland stone, a 4in high Portland stone coping and wrought iron railings on cast steel standards. Roads are to be surfaced with 3½in rolled asphalt, and footways with artificial stone paving.

The highway lighting will consist of three-tube 80W fluorescent lanterns mounted horizontally on concrete columns as at present installed in East India Dock Road. Fluorescent lighting will also be installed in the underpass bridge and in the pedestrian subways.

The north approach extends from Brunswick Road, commencing near the junction with Andrew Street to the tunnel portal, a length of approximately 2000ft. The main quantities are : excavation, 60,000 cubic yards ; reinforced concrete, 300,000 cubic feet ; mild steel reinforcement, 560 tons ; rolled asphalt, 20,500 square yards ; artificial stone paving, 6500 square yards ; Portland stone facing, 3700 square yards ; railings, 3700 lineal feet.

A joint tender from Holland & Hannen and Cubitts, Ltd., and Fitzpatrick and Son (Contractors), Ltd., has been accepted and the total cost of roadworks will amount to £600,000. The work will be carried out under the direction of the Council's chief engineer, Mr. J. Rawlinson, assisted by Mr. F. M. Fuller.

The total cost of the first stage is £1,600,000 (about £1,000,000 has been the cost of clearing property and rehousing), and the entire project may cost £9,000,000. Subject to ministerial approval, the second stage—duplication of the tunnel itself—could be started in about a year's time.

The Blackwall tunnel runs under the River Thames from Blackwall, Poplar, to East Greenwich. It was opened to the public on May 22, 1897, by the Prince of Wales and was constructed by S. Pearson and Sons to the design of the L.C.C.'s chief engineer, Mr. (later Sir) Alexander Binnie. It took five years to build. The tunnel itself is 4470ft 9in in length with an external diameter of 27ft and an internal diameter of 24ft 3in. The carriageway is 16ft wide with 3ft 1½in footways. At the time of its construction Blackwall Tunnel was justly hailed as a magnificent engineering feat.

It is of special interest to note the volume of traffic which evidently was considered sufficient to justify the tunnel economically at that time—911 vehicles per day used the tunnel in 1898. In 1957, the corresponding figure was 13,000.

Financing of Advanced Sandwich Courses

SINCE the White Paper on Technical Education was published in February, 1956, the number of advanced sandwich courses, under which students spend part of the year in a technical college and part in industry, has increased from 100 to over 200, and the number of students taking them from 2000–3000 to 5000–6000. The objective is to raise the number of students to 15,000 to 20,000, and so contribute to the building up of the supply of technologists which the country needs. With a view to stimulating the spread of these courses, particularly among medium-sized and small firms, the Ministry of Education and the Federation of British Industries have been reviewing the arrangements for giving financial assistance to students who wish to take them.

The Federation of British Industries, in a policy statement issued on Tuesday, April 29, states its belief that industry, by enabling selected employees to pursue advanced sandwich courses, in addition to supporting day release schemes, acts in its own as well as in the nation's interest. The Federation recommends to its members that firms which already pay their students' fees and salaries should continue to do so, and expresses the hope that firms sending students on advanced sandwich courses in the future will follow this example, since it stimulates the student's sense of loyalty to the firm and strengthens the firm's ties with the college. Such payments are treated as normal business expenses for tax purposes. The Ministry and the Federation recognise, however, that there are and will continue to be firms who do not feel able to meet the whole cost of such training. There will, therefore, be a continuing number of such students who will look to local education authorities for aid. In a memorandum also issued on Tuesday, April 29, Mr. Geoffrey Lloyd, the Minister of Education, recommends local education authorities to give sympathetic consideration to such applications.

The memorandum indicates the basis on which awards to students taking advanced sandwich courses should be calculated. Where appropriate, London University rates should be taken for students attending colleges in London, and the Civic University rates for students elsewhere. The award should cover the tuition fee in full, except where the income scale requires a parental contribution towards fees as well as maintenance. The Minister advises that in accordance with the normal practice for assessing awards whereby earnings received outside the period of full-time study are disregarded, any earnings accruing to a sandwich course student while he is working in industry should be left out of account unless they are exceptional having regard to his age and circumstances. Some firms may wish to give their students at the beginning of their course an allowance to meet initial expenses ; in the calculation of a student's award any such allowance may be ignored up to the amount of £100.

The Federation's statement informs its members of these recommendations by the Minister and gives guidance on their application from the industrialist's point of view. It recognises that as a further means of encouraging students to take sandwich courses the employer may, after the course is finished, make to the student an *ex gratia* payment in the form of a lump sum, but it suggests that the student's right to this gift should not be absolute but conditional, e.g. it might be payable on the satisfactory completion of the course.

Students who are college-based, i.e. who are recruited by colleges rather than firms, but whom the firms accept into their works for the periods of practical training, will continue to be paid by industry during their works training and to be eligible for financial assistance from the local education authority concerned during their periods in college.

Research into Deep Drawing

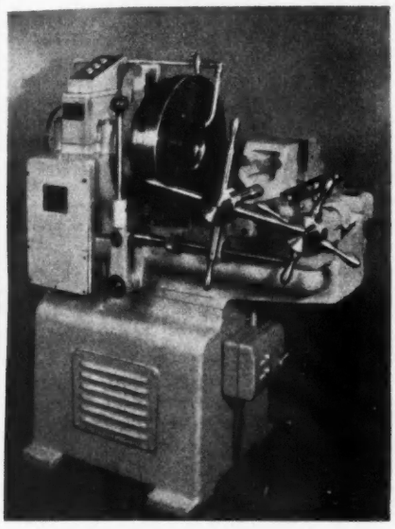
FOR a number of years, the assessment of the suitability of sheet metal for deep drawing and related processes has been investigated by many organisations in various countries. But, owing largely to the lack of effective contact between the investigators, much of the effort expended appears to have been duplicated or even misplaced, with the result that those in need of guidance are faced with a variety of testing equipment without any clear indication of the relative merits of the several testing methods. In order to correct the situation, the International Deep Drawing Research Group was formed last year by representatives from a number of European countries, with the object of exchanging information and co-ordinating further research into methods of sheet metal testing and into other problems arising from the deep drawing of metals.

While valuable work has been done in the past in Great Britain, it is felt that the present arrangements for fostering research and investigation into the deep drawing of metals should now be more broadly based and extended to cover the interests of all concerned with the testing and deep drawing of metals. There have been discussions between the British Iron and Steel Research Association, the British Non-Ferrous Metals Research Association, the Institute of Sheet Metal Engineering, and the Production Engineering Research Association, as a result of which the British Deep Drawing Research Group has been formed. This group is administered by a joint research committee of the sponsoring organisations. The principal function of this research group will be to encourage wider interest in the investigation of problems relating to deep drawing and to serve as a medium for the dissemination and discussion of results and developments. Membership of the group is open to all interested organisations and individuals in Great Britain and the Commonwealth on the basis of membership of the Institute of Sheet Metal Engineering. The group will be responsible for the publication of papers and the organisation of meetings in relation to its activities. Anyone interested in joining the group or obtaining further particulars is invited to communicate with the Hon. Secretary of the British Deep Drawing Research Group, the Institute of Sheet Metal Engineering, John Adam House, Adelphi, London, W.C.2.

Universal Screwing Machine

A UNIVERSAL screwing machine made by Joshua Heap and Co., Ltd., Ashton-under-Lyne, is fitted with a receding radial diehead and is suitable for threading both taper and parallel pipe threads from ¼in to 4in diameter and standard bolts from ¼in to 2in diameter.

The machine, to be seen in the illustration below, is mounted on a cast iron cabinet in which the motor is housed. A push-button control panel for the main 2 h.p. motor is built into the main spindle housing within easy reach of the



4in universal screwing machine for pipes and bolts

operator. The cabinet also contains the tank for the cutting lubricant, which is fed by a gear pump. The driving shaft and worm shaft are connected by interchangeable pick-off gears, enabling four speeds to be obtained. Final drive to the main spindle is through a worm unit.

The saddle slides on rectangular ways over a working travel of 6½in, and its open-jawed vice has two pairs of hardened steel jaws provided for the larger sizes of pipes and bolts. The vice blocks are operated by left and right-hand Acme screws and fitted with rectangular slides.

The cam design radial diehead is fitted with a receding mechanism with instantaneous opening and closing by hand lever. When producing taper threads an adjustable collar on the release rod is in contact with the stop on the carriage as the thread is being cut, the forward movement of the carriage opens out the diehead, to produce a taper thread. When the collar is not in contact with this stop, parallel threads are cut.

Baquba Railway Bridge, Iraq

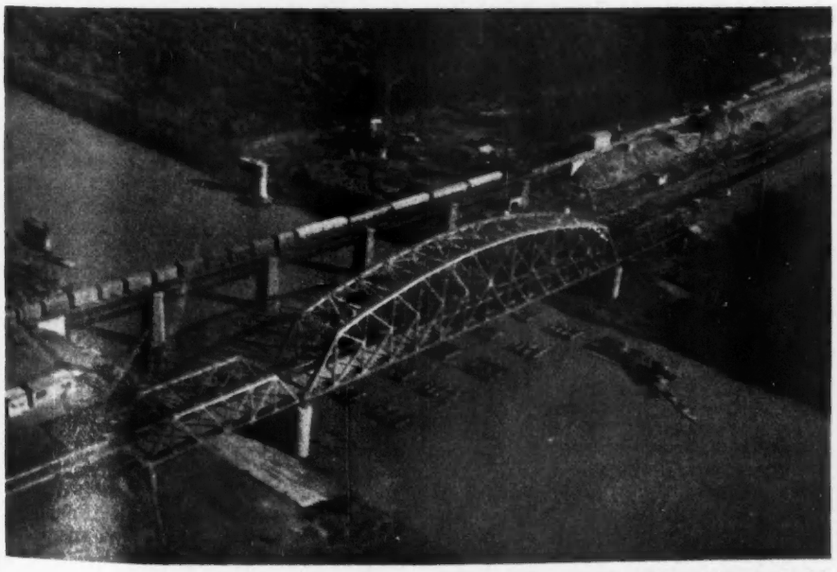
THE opening took place this week of the Baquba bridge in Iraq. The bridge crosses the Diyala River, a tributary of the Tigris, about 30 miles north of Baghdad ; it carries two lines of railway track, and replaces a bridge which carried a single rail line and also road traffic. The illustration below shows the bridge ; the main span is a K-truss 350ft long and there are two Pratt truss approach spans each 110ft long.

High-tensile steel has been extensively used in the principal trusses, 460 tons out of the total weight of 730 tons of steelwork in the 350ft span being high-tensile steel. Similarly, 160 tons of high-tensile steel has been used in the two side spans, whose total steel weight is 270 tons. The members of the central truss were pre-stressed to eliminate secondary stresses.

The bridge is sited in the flood plain of the Tigris and Diyala rivers, where alluvial deposits extend to great depths. Hence, the piers are carried on caissons, and the work was divided according to the time available in the low water seasons. The caissons were sunk and the piers built in the 1956 season, and the steelwork was erected in the following season. The steelwork was erected on timber staging, which has been almost completely dismantled in our illustration of the bridge. Erection of the bridge and removal of the staging had to be completed before the 1958 flood.

The caissons were sunk to sand, through sand, silt and clay. The caissons below the main span were founded 114ft below flood level ; they were built in reinforced concrete, each one being 21ft by 52ft 6in by 72ft 6in. The main piers constructed on these caissons are 42ft by 11ft in cross-section, and are 42ft high. The caissons for the abutments were also built in reinforced concrete, but to a smaller size—15ft by 36ft by 60ft—and they were founded 79ft below flood level. Each abutment pier is 12ft wide by 28ft high, and incorporates wing walls which retain the approach embankments.

Baquba bridge was built for the Iraq Development Board. The consulting engineers were Messrs. Rendel, Palmer and Tritton, and the contractor was Holloway Brothers (London), Ltd.

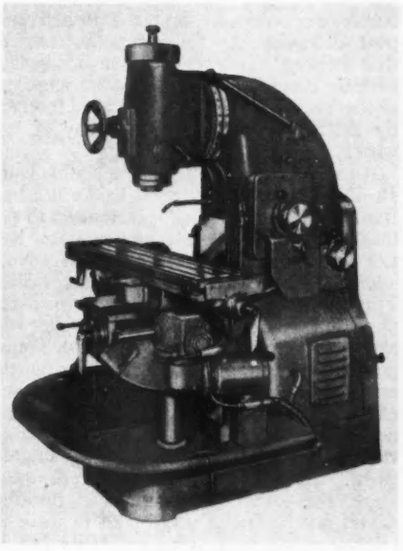


The main span of Baquba railway bridge is a 350ft K-truss, which is carried on r.c. caissons sunk to 114ft below flood level

Vertical Milling Machine

A RECENT addition to the " Richmond " group of machine tools made by Midgley and Sutcliffe, Ltd., of Leeds, is the No. 3 vertical milling machine we illustrate below. It has a long, heavy base, incorporating the coolant tank, and the column of pyramidal design has wide ground guideways for the knee. The speed and feed units are mounted on brackets within the column, and the 5 h.p. main motor is carried on an adjustable swing plate at its base.

The spindle head is adjustable through 45 deg. on each side of the centre line and on it the spindle runs on a pair of taper roller bearings in



No. 3 " Richmond " vertical milling machine

the quill. The spindle has a vertical movement of 3in through a handwheel and it is bored No. 40 standard taper, the diameter of the nose being 3½in. Twelve spindle speeds from 20 to 1000 r.p.m. are available in geometrical progression, and there is an alternative range from 30 to 1400 r.p.m. if required.

The 48in by 11in table is arranged for power feeds up to 30in longitudinally, 8in transversely and 16in vertically. In the longitudinal and transverse directions these feeds are variable from 0·45in to 12·5in per minute, and the vertical feeds are from 0·22in to 6·25in per minute. Rapid longitudinal and cross traverse movements are effected at a speed of 100in per minute, the rapid vertical movement being 50in per minute. Directional feed engagement levers are used on the machine and they are grouped within easy reach of the operator.

Jet Airliners

THE only commercial jet aircraft in Great Britain, the De Havilland " Comet 4," made its first flight this week. The Mk. 4 differs from the earlier airliners in that the De Havilland " Ghost " engines with single-sided impellers have been replaced by Rolls-Royce " Avon " R.A.29 axials with variable-incidence guide vanes. Nineteen are on order for B.O.A.C., of which the first should be delivered this year, and six of the shorter range " 4B " have been ordered by B.E.A.

There is at present only one jet airliner in service, the " Tu.104A." The first flights have taken place of the " Tu.110," which resembles the " Comet " in having four engines in the wing roots, the Sud-Aviation " Caravelle," which has performed scheduled freighting and toured America (the " Comet," when silenced, is externally even quieter than the " Caravelle ") and the Boeing 707, carrying two-spool engines in pods.

Industrial and Labour Notes

Railway Wages

During the past week or so there have been various discussions arising from the final rejection of the wage claims submitted by the three railway unions to the British Transport Commission. At the beginning of last week, representatives of the three unions—the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, and the Transport Salaried Staffs Association—met Sir Brian Robertson, chairman of the British Transport Commission. Following the talks at that meeting, union representatives, together with Sir Brian Robertson and other members of the Transport Commission, were received by the Prime Minister on Tuesday of last week.

A statement issued subsequently from 10, Downing Street, referred to " a full and frank exchange of views." It went on to say that the trade union representatives had urged that the Government should provide additional financial facilities to the British Transport Commission in order to make possible an immediate increase in wages and salaries. The chairman of the British Transport Commission, the statement continued, outlined the action already being taken for effecting substantial improvements in the net revenue position and said that further steps of a similar nature were being investigated. But even taking account of these steps, the Commission's financial position would not justify at present an increase in railway wages and salaries. Nevertheless, the Commission's purpose was to provide sufficient assurances of an improvement in its position to enable it to agree with the unions on a date by which wages and salaries could be reviewed. With that end in view, certain proposals in relation to the railway modernisation programme and other matters had been prepared.

In reply to these submissions, the Prime Minister said that the Government held consistently to the view that arbitration awards should be accepted. The way out of the present difficulty was not by subsidy, but by a concerted effort to increase efficiency and productivity. The Prime Minister went on to make the following proposal : Provided the British Transport Commission and the railway unions were prepared to effect the maximum economy in operation and to join in ensuring the most efficient use of manpower, the Government was prepared to re-examine at once the programme of modernisation and to give the necessary support to the reductions in uneconomic services, as well as to consider any other points put forward by the Commission. The benefits from this should accrue in steadily increased standards of living for all those who worked on the railways.

The detailed economy proposals prepared by the British Transport Commission are now being considered by the Ministry of Transport.

Engineering Exports

The Board of Trade says that, although United Kingdom exports as a whole in the first quarter of 1958 were marginally lower than a year earlier, the largest group, engineering products, showed a substantial rise of about 8½ per cent. The value of engineering exports in the first quarter was £335 million, the highest quarterly total so far achieved. The boom in motor-car exports to dollar markets was the outstanding factor in the engineering group and exports of aircraft and machinery made substantial contributions to the increase. On the other hand, exports of ships and boats were small during the first quarter.

The value of motor-car exports in the first quarter, the Board of Trade explains, was £50,000,000, the dollar markets absorbing half the increase compared with the first quarter of last year. Shipments to the U.S.A. and Canada were worth 83 and 72 per cent more respectively, more than six times as many cars being sent to the U S A. as two years ago. Exports of commercial vehicles and chassis continued to rise, South Africa, Australia and New Zealand being prominent markets. During the first quarter, there were large exports of aircraft to India and Canada. The Board of Trade adds that exports of machinery other than electric have risen substantially almost every year since the war, and the first quarter's increase of 6 per cent, compared with a year earlier, continued the upward trend, though at a rather more modest rate. Agricultural tractors and parts and aeroplane engines accounted for most of the rise in machinery exports, Brazil and South Africa taking the biggest increases in tractors.

Payment by Results

The Ministry of Labour has published an analysis of statistics collected recently concerning payment by results in various industries in the United Kingdom. Information, which related to the last pay week of October, 1957, was received from about 68,200 establishments, and it was revealed that in approximately 29 per cent of these establishments some of the workers were paid under various systems of " payment by results " ; for manufacturing establishments only, the percentage was 38. The total number of workers paid under these systems in all the industries included was over 2,250,000, or nearly 33 per cent of the total number of wage-earners at work in those industries in the last week of October, 1957.

British Iron and Steel

The annual report of the British Iron and Steel Federation has just been published. It is concerned with the progress of the iron and steel industry in 1957, and consequently much of the information has already been circulated. The report is, nevertheless, a useful document for it brings together many facts and figures relating to British iron and steel.

A table of world steel production, for example, shows that in the United Kingdom steel output continued to advance last year, when, in some countries, among them the U.S.A., output had ceased to rise or was declining. Throughout last year steel production in the United Kingdom was consistently above the level for 1956, although the rate of increase lessened during the last few months ; the increase in output over 1956 was, in fact, 6 per cent for the first nine months and 5 per cent for the year as a whole. But the report records that the increase in production was not matched by a proportionate movement in home consumption of finished steel. In the first half of last year consumption was 3 per cent below the level in the same period of 1956. From midsummer onwards there was some recovery in consumption, reflecting in part the higher rate of activity in the shipbuilding, motor vehicle and durable consumer goods industries. By the end of the year, however, the general position was again uncertain. The report points out that imports of steel, which amounted to 1,771,000 ingot tons in 1956, fell to 953,000 ingot tons last year. This reduction, it is observed, might have been greater but for the existence of long-term contracts which could not be cancelled at short notice.

Changes in Wage Rates

Changes in wage rates, reported to the Ministry of Labour as taking effect in March, resulted in an aggregate increase of approximately £101,000 in the weekly full-time wages of 232,000 workers, and in an aggregate decrease of £250 for about 10,000 workers. The decreases, which operated under sliding-scale arrangements based on the official index of retail prices, affected certain groups of workers in the mining and quarrying and iron and steel industries.

Among those who received wage increases in March were operatives in heavy chemical manufacturing establishments in London and workers in various engineering grades in the Post Office. In the first three months of this year, the Ministry of Labour states, changes in wage rates led to an aggregate increase of £503,000 in the weekly full-time wages of 2,371,500 workpeople. This compares with an increase of £659,000 in the weekly full-time wages of 3,007,000 workpeople in the corresponding quarter of 1957. The index of rates of wages (January 31, 1956=100) stood at 113 for all workers at the end of March, indicating a movement upward of one point since the end of last year ; for the manufacturing industries only, the index number at the end of March was 112 for all workers, at which figure it has stood since last August.

The A.E.U. National Committee

The annual meeting of the Amalgamated Engineering Union's national committee began last Monday, at Great Yarmouth. The opening address by the president, Mr. W. J. Carron, contained observations on the Cohen committee's recent report, on the forty-hour week (see page 643), and on trade union organisation. On this last-named topic, Mr. Carron said that the restraint of the British trade unions in the use of the " power motive " was to be commended. The " wild-cat " strike was always a possibility, especially where bad tempers predominated and there was an absence of the will to discuss fully the matter in hand. But, Mr. Carron continued, the widespread industrial stoppage was practically unknown or seldom met in this country. To organise a total lock-out or a complete industrial stoppage would be a comparatively simple matter in these days ; to pick up the pieces afterwards was a vastly different exercise !

The question for consideration, Mr. Carron went on to say, was not the strength of the negotiating parties, but rather the way in which that strength was used and controlled. He felt sure, however, that the " vast bulk of our discerning British public, although they might be sometimes inconvenienced and very often sorely tried," would react very violently indeed to any move intended to compel a workman to serve in conditions which he did not consider acceptable to him.

German Industries Fair, Hanover

No. I

At the twelfth German Industries Fair, which opened on Sunday, April 27 and closes on May 6, there are some 4000 exhibitors, including about 500 from abroad. Among them are some seventy-five British firms and their German representatives. The general layout of the Fair is shown below. In addition to the sixteen large halls and two multi-storey buildings provided by the exhibition company, there are several large pavilions built by individual companies or groups, notably from the iron and steel industry. Some 70 per cent of exhibition space is stated to be let under long-term agreements for periods of up to ten or twelve years. British and foreign firms have also taken long leases at the Fair. The growth of the Fair is illustrated in Table I:

TABLE I.—*Development of Hanover Fair*

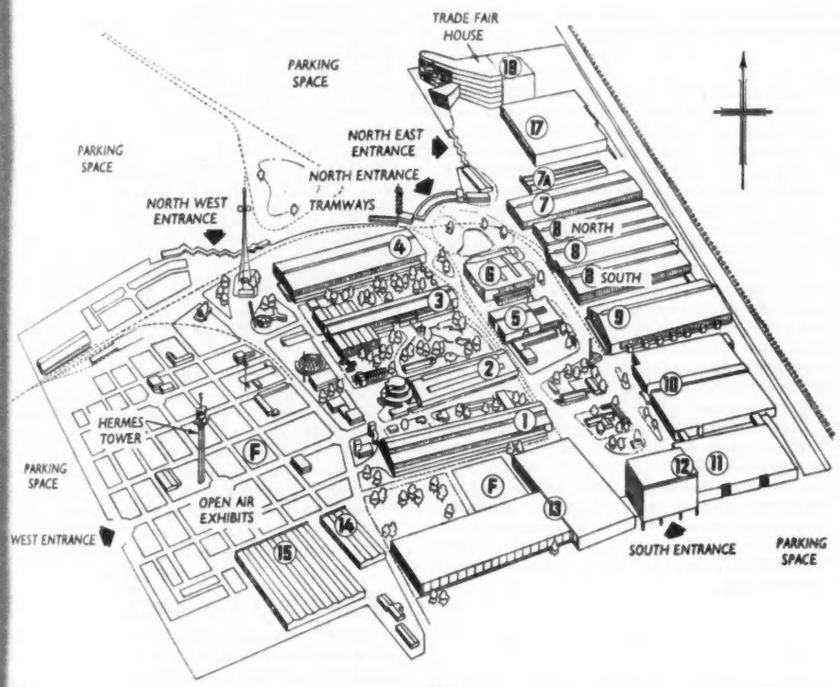
Year	Halls, square metres	Open area, square metres
1947	30,000	8,000
1948	55,000	11,000
1949	49,000	16,000
1950	75,000	30,000
1951	144,000	40,000
1952	150,000	45,000
1953	150,000	55,000
1954	205,000	55,000
1955	220,000	75,000
1956	230,000	120,000
1957	240,000	140,000
1958	270,000	140,000

New Buildings

For a long time the exhibitors of electrical manufactures were housed in temporary buildings and were thus forced to expend large sums for the erection and dismantling of their stands. Since the electrical industry, of which well over 1000 firms are participating, already several years ago decided to make the Hanover Fair its only exhibition, there were strong reasons for improving the situation, particularly as the mechanical engineering industries are also expanding and have already laid claim to the large permanent Hall 9. It was therefore decided to find a thorough-going solution of these problems, and to construct four new buildings, viz., the two-storey Hall 11 (sound reproduction equipment), the five-storey Messehaus 12 (lighting fittings), and the large Hall 13, of 25,000 square metres area (heavy electrical equipment). Together with the double-storey Hall 10, the electrical industry now disperses over an area of 96,000 square metres. In addition, the industry's open-air exhibition area has been increased by 3500 square metres.

Some further particulars of the three new buildings may be of interest. In all three the load-carrying structure is of reinforced concrete, with a steel roof. Hall 11 is, as already mentioned, connected with Hall 10 and has glass-covered stairways which give excellent natural lighting. It has a length of 120m, a width of 87·5m and a height of 12m, giving headroom of about 4m to each of the two storeys. On the eastern side it has a ramp leading to the first floor.

Experience with a similar ramp fitted in the office equipment industry building (No. 17) has already proved the advantage of this arrangement.



Hall
1—Pumps, compressors, valves and fittings, measuring and control instruments.
2—Power transmission mechanisms, ball and roller bearings.
3—Internal combustion engines, nuclear engineering and industrial furnaces.
4—Chemical preparation plants, machines for rubber, plastics, ceramics and hoists.
5—Precision tools and gauges, optics, photographic supplies.
6—Chemistry and plastics.
7 and 7A—Textile machinery and accessories.
8 (North)—Air conditioning plants, refrigerating plants, food production and packing, weighing and laundry machines.
8 and 8 (South)—Woodworking machinery.
9—Tools, measuring instruments, grinding and polishing machines, welding and flame cutting.
10 and 11—Electrical engineering.
11—(Lower floor) Radio and television.

Hall
12—Electric lamps and lighting fittings.
13—Heavy electrical engineering.
14—Rubber, asbestos and non-ferrous metals.
15—Building materials and accessories, oil-firing plants and workshop supplies.
17—Office machinery and drawing-office equipment.
18—(Trade Fair House) Glass, ceramics, silver ware, watches, clocks and jewellery.
In front of Hall 18—A special show of industrial products.

Open-Air Exhibits
In front of Halls 9 and 11—Electrical engineering exhibits.

Main Open-Air Space
Building machinery, road construction plants, steam and diesel locomotives, road transport vehicles, garage equipment, loaders and conveyors.

Hanover Fair grounds

In Hall 12, which houses the exhibition of lighting fittings and lamps, the floor area is about 50m by 70m, the overall height being approximately 49m. All the stairs, lifts and plant accommodation, for ventilation and heating, are accommodated in a central space. Some 10,000 square metres of exhibition space have been provided. Hall 12 is a five-storey building on high columns with passages between them forming the new southern entrance to the Fair Grounds. The new Hall 13 for the heavy electrical industry, which has an L-shaped plan, has been designed to accommodate the stands of some 120 companies, and some of the larger firms will have their individual stands of more than 1000 square metres, with conference rooms in the upper part of the stand building. The hall is equipped with eight special roller gates, 5m in height, which will allow loaded trucks and wagons to drive right into the hall for unloading purposes. In this building there is accommodation for a number of British, Belgian, Danish, French, Austrian, Swedish and Swiss firms.

New building was also carried out in connection with the expansion of Hall 2, which is reserved for gears and drives, and where the accession of leading firms in the ball bearing and roller bearing industries necessitated more space. The width of the hall was increased by 14m, making a total width of 40m, which now allows a total space of 4800 square metres, providing for the stands of sixty-five firms.

Other work was carried out in the former hall block 8/8B, by the building of a third bay, giving 8500 square metres of further exhibition space. This bay was built in three months, and some 693 tons of steel had to be erected. It is 51m in width and 14m high, and was used during the recent European Machine Tool Exhibition. The whole block now comprises three bays, and provides 25,400 square metres of exhibition space. It is reserved for the mechanical engineering industry. All the halls are furnished with railway tracks, overhead cranes, large gates and additional ramps, as well as with modern heating, ventilation and lighting. It is of interest to note that the floor of Hall 8 has a load bearing capacity of 10,000 kg per square metre.

Road Access Improvement

It is reported that the Autobahn from Hamburg to Hanover, now under construction, will take a course towards the south, in the direction of Kassel and Frankfort-on-Main, quite close to the Fair Grounds, so that a very good connection with the Autobahn network is thereby ensured. Attention has also been given to the provision of more parking space for motor vehicles and a new parking place in the north-west of the grounds has been laid out for 2800 cars, giving a total parking area of accommodation for some 34,000 motor vehicles.

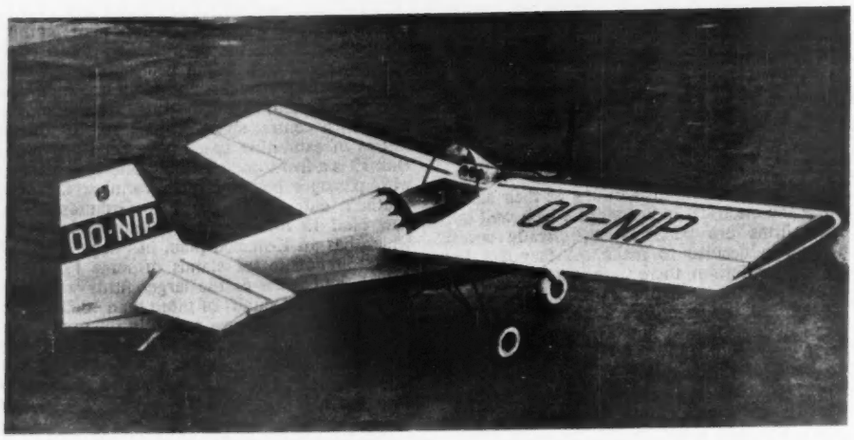
In what follows we shall present a survey of some of the exhibits.

Demag Aktiengesellschaft

Among the exhibits shown by Demag A.G. at Hanover this year is a copy of the model built for the ECSC pavilion at Brussels, showing the whole series of processes from the winning of iron ore to the rolling of the steel into sheet, sections, rods and wire. Besides a full range of standard products, including hoists and cranes up to an 8-ton crane of 16m radius, are compressors and compressed-air tools.

Of particular importance is an axial-flow compressor of 100,000 cubic metres of free air per hour, with a delivery pressure of 2·3 atmospheres, which will be installed as a blast-furnace blower. The axial-flow design, it is claimed, has an efficiency 8 to 10 per cent higher than that of a comparable radial-flow compressor. Besides this, the machine utilises what is stated to be a new method of regulation. Normally, the output can be varied by altering the number of revolutions per minute and the angle of the intake guide vanes, but only within narrow limits. Here the range of efficient operation is widened by diverting any surplus air which becomes available when the demand drops, into an air turbine situated on the same shaft as the compressor.

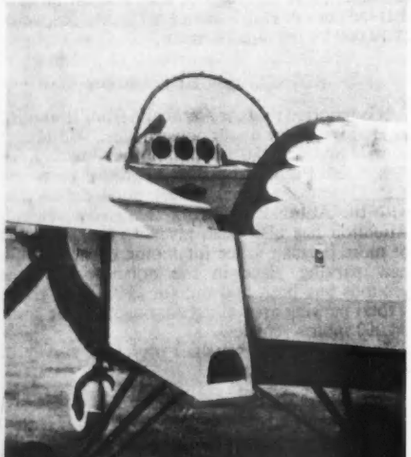
(*To be continued*)



The Tipsy "Nipper" has a simple structure with wooden wings and a welded steel tube fuselage, covered with fabric and with glass-fibre-reinforced plastic fairings

Low-Cost Aircraft

There is to be produced by Avions Fairey S.A., Belgian subsidiary of the Fairey Aviation Company, Ltd., a cheap light-weight aeroplane called the Tipsy "Nipper." Designed and developed by the managing director of the Belgian firm, Mr. E. O. Tips, it contrasts with the particularly clean "Tipsy" of twenty years ago in being a shoulder wing monoplane of simplified construction : it will be available either complete or as a kit of parts for assembly by amateurs. The standard engine is a Volkswagen unit of 30 h.p., giving a cruising speed of 65 m.p.h.. The low weight of this engine has caused it to be widely used for aircraft, and dual ignition versions are available. If the aircraft is to be used for



Access to the cockpit requires part of the trailing edge to be hinged down. Notice the linkage to steer the nose-wheel and the cable-operated disc brakes

reasonably long flights, the related Porsche engine is recommended.

Such light aircraft naturally need to place the pilot near the centre of pressure to avoid ever needing to carry ballast, and this usually results in high wing or even parasol designs. The "Tipsy" was an exception, but the low wing layout was probably regarded as prone to damage for a very small aircraft operating on inferior flying fields. The intermediate position presents the problems of pilot's visibility and access : the latter has been solved by providing a large light alloy flap in the root trailing edge of one wing which drops down to act as a step.

The wing has a single spar, with top and bottom faces parallel and of constant width : the ribs are glued-up Warren girders, and the leading edge is covered in 1mm ply. The fuselage is a steel tube structure, welded together and having the attachments bronze welded. The rudder—there is no fin—is also metal, fabric covered. The undercarriage is sprung by Nieman rubber rings and has the generous travel of 11in on the main wheels. The wheels run on what are described as maintenance-free auto-lubricating plastic bushes. Behind the glass-fibre reinforced plastic engine cowling the light alloy fuel tank forms the top deck of the fuselage, while the lower fuselage fairing is another moulding and is detachable for access to the pilot's controls and the working parts of the undercarriage.

The kit of parts, which includes the completed fuselage, undercarriage and other metal components, is packed in a case 11ft 6in by 2ft 8in by 2ft 4in (weighing less than 400 lb gross), on the inside faces of which are painted outlines of various components so that it can be made into construction jigs. Engine, cowling, propeller, instruments, fabric and paint are not included in the basic kit.

Coal Preparation Congress

The Third International Coal Preparation Congress will take place in Brussels and Liège, Belgium, from June 23 to 28, 1958. Technical visits have been arranged for that week and the following week. The organisation has been undertaken by the Institut National de l'Industrie Charbonnière (Inichar), 7, boulevard Frère Orban, Liège, Belgium.

This Congress deals with the preparation of small coal, smaller than ¾in. There are sixty-seven specialist papers, several of which deal with the maximum efficiency in coal preparation and use in coke ovens and power stations. All the papers will be published in English, French and German before the Congress opens. The technical sessions will be held at Liège. They will be heard in the three languages with simultaneous translation.

Technical visits include mines in the coalfields of Liège, Campine, Limburg, and Aachen, during June 23–28 ; and Mons, Centre and Charleroi, Nord and Pas-de-Calais, Lorraine, Saar, Ruhr, and Great Britain during June 30–July 5, Visits are scheduled to research establishments at Limburg, Verneuil-en-Halatte (Lorraine), and the Central Engineering Establishment at Bretby.

Tiled Partitions

For the construction of tiled partitions, the firm of Herbert Lux, Radebeul 1, Stalinstrasse 139, German Democratic Republic, has put on the market a range of plastic spacers by the use of which this class of work is stated to be greatly facilitated. The spacers are made of plastic and are designed for 4mm or 6mm thick tiles. They are placed at the corners of the tiles, so that each helps to hold in position eight tiles, four on each side of the partition. The design comprises two parts. One consists of four rectangular spacer strips 30mm long, their length being equal to the thickness of the finished wall. The strips are continued at each end by a narrow section equal in width to the spacing between adjoining tiles, i.e. less than 3mm, and connected at one end by a plastic ring. After the eight tiles have been erected in their correct positions by means of this part of the device, the spacer is locked by pushing a plastic ring over the free ends. When the whole wall has been completed and after any reinforcement rods have been placed in position, the assembly is filled with thin concrete. As soon as the concrete has set the spacer rings are removed and any remaining strips of plastic in the gaps are knocked out, the main portions of the spacer being left in position inside the wall.

Paper Mill Extension

A large plant for the production of cardboard was inaugurated on March 22, at the Arnsberg works of Feldmühle Papier und Zellstoffwerke A.G., Düsseldorf. This increases the productive capacity of the works to over 100,000 tons per annum, making it the largest single-production unit in the Common Market. Last year the total output of cardboard from 400 factories in the Common Market area amounted to 1,700,000 tons, of which more than half was produced by fourteen undertakings with a capacity of 60,000 tons and over. All the production at Arnsberg is high quality cardboard for boxes. Last year West Germany produced 200,000 tons of this grade, half of it being made by Feldmühle.

The new plant entailed an expenditure of DM.60,000,000 (DM.45,000,000 for cardboard making machinery and DM.15,000,000 for a new boiler plant, erected in 1956). Working in a fully automatic manner, the plant requires for its control only six operators. The new line, which has a daily capacity of 150 to 200 tons, is nearly 300m long, of which the machine occupies 134m. The other two production lines have a combined capacity of 150 tons. During the last ten years the number of employees at this factory has more than doubled, to reach a figure of nearly 800, while output has increased over fourfold.

550,000 New Housing Units in 1957

550,000 new apartments ready for occupation were completed in 1957 in the Federal Republic and West Berlin, according to preliminary figures just released by the Federal Office of Statistics. This signifies a decrease of 5 per cent in comparison with the record-breaking figure of 1956, during which 581,600 apartments were completed.

As in 1956, over half of all housing units—a good 52 per cent, to be exact—were built as part of the publicly-supported Social Building Programme without private financing. Privately-financed houses receive only tax benefits as a form of public support.

Excluding West Berlin, for which figures are not yet available, "overlapping" construction—that is, housing units under construction but not completed at the year's end—is estimated at 344,000 apartments, approximately 5 per cent below the figure of the previous year. On the other hand, the number of housing projects licensed but not yet started, 161,000 in number, was some 8 per cent lower than during 1956.

Activity at the Port of Basle

Last year, the volume of goods passing through the port of Basle amounted to 5,400,000 tons, the highest annual figure reached so far. This represents 37·6 per cent of the total Swiss import and export trade of 14,400,000 tons. In particular, imports of solid fuel, crude iron, seed grain and vegetable oils account for much of this increase. Import of solid fuels amounted to 3,500,000 tons, an increase of 12·2 per cent over the preceding year, and only surpassed once before, in 1939. This increase was largely the result of the Suez crisis. During the year, 10,189 ships arrived at Basle, an average of twenty-eight per day.

American Nuclear Engineering Conference

BY OUR AMERICAN EDITOR

No. II—(*Continued from page 637, April 25*)

The fourth Nuclear Engineering and Science Conference was held at the International Amphitheatre in Chicago, Illinois, from March 17 to 21, in conjunction with the 1958 "Atomfair" exhibition. The conference was organised under the sponsorship of the American Nuclear Society in co-operation with twenty-eight other American and Canadian engineering institutions. The exhibition was sponsored by the Atomic Industrial Forum and presented a comprehensive picture of the current state of development in the application of atomic energy in American industry.

Atomic Industrial Forum

THE Atomic Industrial Forum, of New York, sponsored this year's "Atomfair" exhibition and also helped to organise the various sessions of the Nuclear Congress. The forum is a non-profit membership association of more than 500 industrial firms, research and service organisations, labour groups and educational institutions engaged in the development and utilisation of nuclear energy for constructive purposes. It provides its American and overseas members with a broad programme of activities and services designed to assist them in finding solutions to problems imposed by atomic energy in such areas as management, technology, economics, business practices, legal problems, health and safety, marketing, insurance, education and training. This is accomplished through national, international and regional meetings, the operation of committees, special studies, publications and exhibits.

The Forum recently has been among those in the United States who have realised that the nuclear industry must now recognise and articulate a number of severe problems. Fortunately, the prospect of a major world market has appeared at a fortuitous time to mitigate what appeared to be a developing area of disillusionment with the atom, at least within the United States atomic industry. The hard lessons of experience have begun to make clear that nuclear power development is a difficult and costly enterprise—more difficult and more costly than was at first generally presumed. There is still great confidence within the industry that economic problems in the United States will be solved by advancing technology. But the reappraisal now in progress has already shown that a truly profitable atomic enterprise in the U.S. is farther in the future and will require more effort to achieve than had been first estimated.

During the past year, moreover, it has become increasingly clear that the nature and extent of future Government assistance will be subject to conflicting philosophies, and correspondingly unpredictable. It is hoped, therefore, that the prospective world market will make it possible to bridge the gap between the uneconomic present and the day when industry can stand on its own feet, and on its own investment and not on Government assistance subject to political vicissitudes. The basic problem on the domestic scene has to do with the return industry receives for the work it performs in the atomic field. The level of this return is necessarily an important factor in the determination by many company managements, particularly those of small concerns, of the degree of their interest in entering or remaining in the atomic energy field. Although industry in the past has been willing to operate at a loss or with very low profit margins so far as atomic energy work is concerned, there is a serious question how long this practice can be continued.

It is naturally in the interest of the public for as broad an industrial base as possible for the United States atomic energy enterprise to be established. But it is also clear that the sooner a profitable situation is realised, the healthier and sounder will be the base of the atomic industry, from which so much is expected, both here and abroad, in future years. In any case sound development of atomic industry will require sympathetic understanding and co-operation between Government and industry. There also must be public understanding of a high order. Reasonable legislation and regulation can only be assured through a well-informed public. For example, if there should be a nuclear incident, even though its effect on the public welfare were of much smaller proportions than the effects of accidents experienced by more conventional industries, an unduly frightened public could become a vindictive public. The regulations which could result as a consequence might put intolerable obstacles in the path of the entire future of the atomic industry. Never before in a technological development have industry and Government had to work so hard and so painstakingly to ensure the public safety.

One of the specific reasons for the existence of the Atomic Industrial Forum is to identify and seek solutions for these and other problems. Already in its short life of four years the Forum has made substantial contributions to the development of this industry. The Forum is proving to be a useful meeting place for all segments of the American and international economy interested in atomic energy development. The activities centred around this meeting place of common interests are serving to point the way to solutions of important problems and to illuminate more clearly the opportunities of this vast energy source which lie ahead.

The 1958 Nuclear Congress

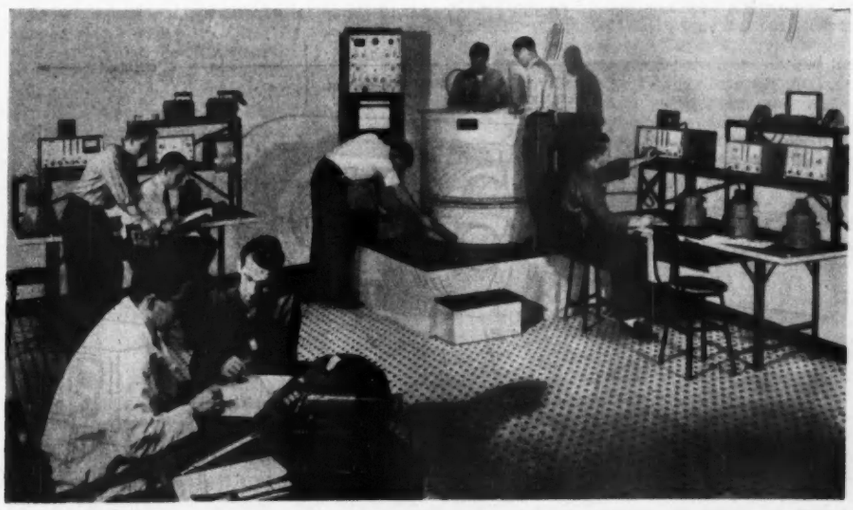
In addition to the "Atomfair" exhibition, the 1958 Nuclear Congress included the fourth Nuclear Engineering and Science Conference, the Atomic Energy Management Conference and the Sixth Hot Laboratories and Equipment Conference. Altogether more than 200 technical papers and panel sessions were presented during the congress. The highlights of the week included several banquets with speeches by Richard M. Nixon, the Vice-President of the United States, Representative Carl T. Durham, the Chairman of the Joint Congressional Committee on Atomic Energy, and Robert M. McKinney, the permanent U.S. Representative to the International Atomic Energy Agency in Vienna. The United Kingdom was represented at these social functions by Sir George Thomson, F.R.S., Master of Corpus Christi College, Cambridge.

The "Atomfair" included more than 100 exhibits from the U.S. and abroad. The displays offered covered such items as design engineering services, package power reactors, medical and research reactors, construction and fabrication techniques, controls systems, reactor materials, instrumentation, particle accelerators, measuring instruments, laboratory equipment, fuel elements and other reactor components.

Nuclear-Chicago Corporation

An unusually interesting development received its initial public display at the stand of the Nuclear-Chicago Corporation, of Chicago, Illinois. It involves a complete nuclear training "package" for colleges and universities. As shown below, the equipment includes a completely equipped Student Sub-critical Reactor, a related laboratory of nuclear measuring and recording instruments, and detailed experiments for students and instructors. The heart of the firm's package is a small, water-moderated, natural uranium sub-critical reactor. This is the first time a reactor of this type has been made commercially available in the United States. The inherent safety and simple construction of this versatile, easily maintained unit make it ideally suited for teaching purposes. Small and highly flexible, the unit can be readily dismantled and the uranium rods or neutron source positions easily changed by instructors or students. The open construction used provides easy access to the internal assembly, facilitating experimentation and instruction. Since the moderator is water, students actually can see the exact position of a detector or foil placed within the uranium lattice. Unlike a critical unit, the Nuclear-Chicago student reactor eliminates the hazard of a runaway, and needs no complicated shielding, costly cooling system or involved safety programme. Its primary function as a teaching tool rather than a research facility makes it constantly available. Operator licensing is not required for the student reactor—direct and continuous use can be had by instructors and students alike.

The reactor consists of a segmented 6ft high, 4ft diameter stainless steel tank. It contains 435 gallons of tap water which act as moderator and shield. Immersed in the water is a lattice of watertight aluminium tubes held in place by two grid plates. Natural uranium fuel, in the form of aluminium jacketed slugs, is placed in



"Nuclear-Chicago" student nuclear engineering laboratory with sub-critical reactor, scintillation well counter, strip foil analyser, survey meters, neutron monitor, scintillation detector and gamma-ray recording spectrometer

the tubes. A neutron source, such as plutonium mixed with beryllium, is generally placed at the centre of the lattice, but can be positioned at any point within the structure for experimental purposes. The reactor in operation weighs somewhat less than 5 tons. Included with the reactor is a transparent dust and safety cover, a calibrated source positioning mechanism, foil handling and positioning equipment, source handling apparatus, and a port for an external neutron source such as a Van de Graaff generator. The entire assembly is installed at the job site with a platform and walkway which provides easy access to the reactor interior and distributes the weight of the assembly over a reasonable area.

A manual of more than thirty nuclear experiments is provided with a complete package consisting of the reactor and the associated nuclear instruments. The experiments are divided into three groups. The first set is designed to familiarise students with basic nuclear detecting and measuring devices and analytical methods. The second set covers methods and procedures used to determine the properties and behaviour of particles and radiations. The third set covers actual reactor experiments and determinations on neutron flux, neutron activation, and other reactor properties.

The lattice of the reactor consists of two grid plates which hold and position 275 aluminium tubes 1·25in in diameter by 43in long arranged in a hexagonal pattern. The wall thickness of the tubes is 0·035in. The tubes are designed to hold 1in diameter by 8in long natural uranium slugs which are available to American schools under the A.E.C. assistance programme. These slugs are cased in aluminium. The total weight of the natural uranium is 5500 lb.

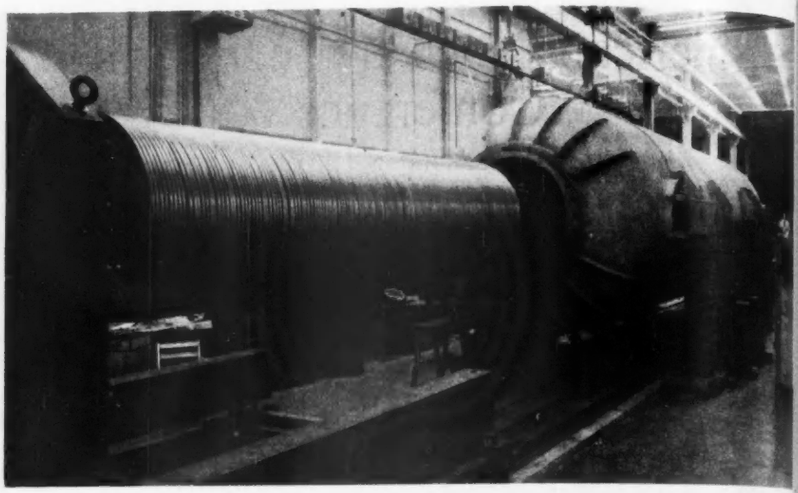
The plutonium-beryllium sources are loaned by the Mound Laboratories of the A.E.C. to schools without charge and are generally recommended for use in sub-critical reactors. They have a long half-life (24,000 years) and emit less than 0·7 gamma for one neutron. The A.E.C. will furnish up to 5 curies of plutonium-beryllium to schools. The source is supplied in one curie sizes 1·02in in diameter by 1·3in high. Radium-beryllium and polonium-beryllium sources are also available. The central region flux of the reactor using a one curie plutonium-beryllium source is approximately 10^4 neutrons per square centimetre per second.

High Voltage Engineering Corporation

A new Van de Graaff particle accelerator designed especially for pulsed neutron output in conjunction with sub-critical assemblies, reactor design studies and nuclear engineering training, was announced by the High Voltage Engineering Corporation, of Burlington, Massachusetts, at the exhibition. The compact positive-ion accelerator, illustrated below, was developed as a result of studies conducted in co-operation with physicists and educators throughout the United States, many of whom are presently working with reactor sub-critical assemblies. The so-called model "PN-250" has an energy rating of 0·25 MeV, nominal, with ion current during pulse of 50 microamperes, nominal. The pulse length is 100 microseconds; this figure, however, is adjustable to pulse lengths in the 25–250 microsecond range at the option of the user. The pulse rise and decay time is less than 5 microseconds, with a pulse repetition rate of 400 pulses per second, nominal and synchronous with the alternator supplying the ion-source power. The weight of the new accelerator is 1200 lb.

The firm's display this year also stressed the utilisation of specially designed Van de Graaff accelerators as injectors for very high-energy electro-nuclear machines. At the Brookhaven National Laboratory, a 4MeV Van de Graaff accelerator has consistently demonstrated its reliability and precision, operating as a pulsed proton source to the 3BeV Cosmotron on an uninterrupted daily schedule for periods of several weeks in duration. A similar machine has been supplied to the French atomic energy laboratory at Saclay. Smaller Van de Graaff electron accelerators, in the 1 to 3MeV range, are designed as pulsed injectors to electron linear accelerators and synchrotrons at the Massachusetts Institute of Technology, Cornell University, and the University of Bonn.

Until recently, the practical maximum particle energy attainable with a Van de Graaff was between 6 and 8MeV. To increase the particle-energy range of the Van de Graaff, a new design principle has now been put to work in a 10MeV tandem Van de Graaff, the prototype of which was ordered by Atomic Energy of Canada Limited, for their Chalk River establishment. With this new design, physicists expect to be able to explore nuclear regions hitherto unattainable with normal techniques of particle acceleration. A model of this machine was exhibited at Chicago, and the shop assembly of the generator is shown above.



10MeV tandem Van de Graaff particle accelerator during shop erection at the High Voltage Engineering Corporation

The new tandem design doubles the useful range of energy obtainable with the Van de Graaff type of accelerator, while retaining the advantages of energy homogeneity, excellent beam collimation, low radiation background, continuous control of beam intensity and simplicity of operation and maintenance. In addition, the tandem design has the following distinctive advantages in many research projects. The ion source is at ground potential and is outside the pressurised region of the machine. This makes possible the development of sources for heavy ions, for pre-acceleration analysis of ions, and for pulsing and bunching. Any of these can be accomplished without restriction due to the limitations of space, electric power, cooling, vacuum pumping and accessibility. Furthermore, the high-voltage terminal contains a minimum of apparatus. Except for the electron stripping canal, there is virtually no apparatus within the high-voltage terminal of the tandem Van de Graaff. Consequently, it is seldom necessary to open the pressure vessel for service or adjustments.

There follow some of the new fields of research which can be opened by the 10MeV tandem Van de Graaff machine.

(*a*) Freedom from restrictions formerly imposed by limited particle energy permits detailed studies of nuclear-energy levels of isotopes to be made through the entire periodic table.

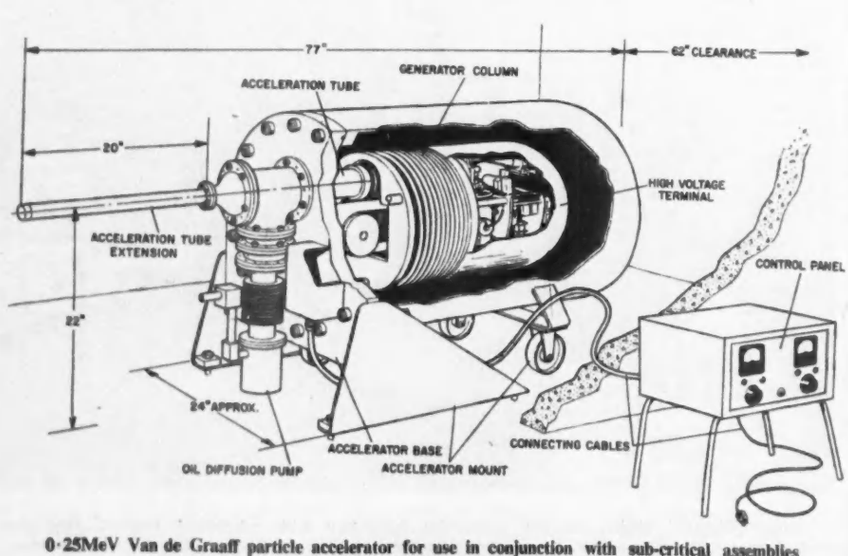
(*b*) The energy homogeneity and the range of energy selection allow the same instrumentation to be used throughout a systematic exploration of levels, using the independent particle model for light nuclei and the collective model for heavy isotopes; this minimises the effect of systematic discrepancies among experimental set-ups.

(*c*) The high bombarding energies available from this machine provide means for studying reversible nuclear reactions to check current theories of nuclear structure; likewise, the (d,p) and (p.d.) stripping and inverse stripping processes can be studied in great detail, with wide choice of reaction parameters.

(*d*) These high bombarding energies also aid in the study of endothermic reaction thresholds for the accurate determination of the masses of nuclei; they also make it possible to obtain relatively high yields of radioactive isotopes for the analysis of decay characteristics.

(*e*) The combination of high bombarding energies and broad energy range provides freedom of reaction selection, thus contributing to a more effective study of compound nuclei.

(*f*) The very broad mono-energetic neutron spectrum (from a few keV to 27MeV) obtainable permits a systematic study of neutron cross



0·25MeV Van de Graaff particle accelerator for use in conjunction with sub-critical assemblies and for training purposes

ections and neutron-produced nuclear reactions itherto unobtainable.

(*g*) The characteristics of this machine allow ndamental particle reactions to be carried out much higher particle energies than possible fore, yet with the same precision that has been und necessary for data analysis.

(*h*) High pulsed beam currents and a wide nge of pulse characteristics are, in principle, hievable because the ion source is external, and ace and power limitations are removed from lsing or bunching equipment; and

(*i*) The feasibility of accelerating heavy ions ens new research areas; because the traditional rangement of heavy target nucleus and light mbarding ion can now be reversed, a new nge of scattering angles can be investigated.

The voltage-generating assembly of the machine mprises two columns, each of 144in insulating ngth, which are mounted horizontally with a mmon high-voltage terminal. Each column nsists of electrically insulated equipotential anes and their associated voltage-dividing sistors. In one column are incorporated the harging belt, charging-belt spacers, gradient ars, and insulating control cords for high-oltage terminal components. The columns are ounted on the two end flanges of the pressure ssel and can be individually withdrawn on heeled carriages. On one of the end flanges are so mounted the belt-drive motor, charge-ansferral means, control selsyns, and electrical nnections. Normal service is performed through ccess portals on the side of the pressure vessel, ithout accelerator disassembly.

The steel pressure vessel is approximately 8ft diameter and 34ft long, and is constructed in ccordance with the A.S.M.E. Code Regulations r Unfired Pressure Vessels. Included with his vessel are a pressure gauge, relief valve, xternal piping connections, access portals, nerating voltmeter, corona-point assembly and ater-cooling coils.

In this new machine, negative ions are accelera-ed to the high voltage terminal, converted to ositive ions by an electron-stripping process, nd subsequently accelerated to ground potential. he negative ions are produced from an intense ositive-ion beam at ground potential, the beam s focused and accelerated into a gas chamber here the ions acquire an excess of electrons. fter additional focusing, energy analysis, and re-acceleration, the negative-ion beam is in-ected into the Van de Graaff and accelerated to he high-voltage terminal. The power supplies nd controls for this negative-ion source are all at round potential. They are situated on the heeled carriage, near the negative-ion source. uxiliary vacuum pumping equipment is included o pump the electron-capture chamber and ion-ource region.

Both the negative- and positive-ion acceleration ubes are multiple-section in design, with highly haffed electrodes of proper geometry and spacing o obtain uniform acceleration and precise ocusing of the ion beams. A highly polished tainless steel terminal connects the two voltage-enerating columns electrostatically. Inside the erminal region are included the charging belt ulley with a built-in permanent-magnet alterna-or for terminal power and the electron-stripping hamber with its remotely-operated controls.

Atomic Energy of Canada

A large gamma radiation cell was demonstrated t the stand of Atomic Energy of Canada imited, of Ottawa. The high radiation fields ndicated below occur when this so-called Gammacell 220" is loaded with sufficient cobalt 0 to provide a dosage of 10^5 röntgens per hour t the mid-point of the irradiation cavity when the avity is in the irradiate position. If the mid-oint dose rate is greater than 10^5 röntgens per our, the fields in the irradiation cavity and xternal to the unit are increased proportionally. When the cell is used to cover fields within the adiation cavity a cobalt source activity of 1·80 curies (nominal) produces a mid-point dose-ate of 10^5 röntgens per hour. The dose-rate t top centre of the irradiation cavity is 23 per ent less than that at the mid-point, whereas the ose-rate at the wall of the cavity opposite the id-point is 21 per cent higher than that at the id-point. The dose-rate in the irradiation avity while in the load-unload position is 2·4 milliröntgens per hour per 10^5 röntgen per hour at the mid-point.

When the cell is in use, the average external field 1m from the centre of source is 0·18 mr per hour, the maximum field 1m from the centre of source is 0·73 mr per hour, and the average field 5cm from the operating face of the unit is 1·0 mr per hour. These fields occur when the cavity is in the irradiate position. The fields are considerably reduced when the cavity is in the load-unload position. The "Gammacell" capacity cannot be stated as a fixed value as it is dependent on various factors to be stipulated by the user in conjunction with the atomic energy regulations within his country. These factors include:

(*a*) Maximum fields permissible external to the unit;

(*b*) Whether accessibility to the unit is restricted; and

(*c*) Estimated working time adjacent to the unit.

The radiation fields given above are used to calculate capacity dependent on several example conditions.

Limiting Conditions	Mid-point dose rate (r/hr)	Nominal Curies, CO 60
(1) The average radiation field at 1m from the mid-point of the source shall not exceed 2 mr per hour and the maximum shall not exceed 10 mr per hour over localised areas.	$1·1 \times 10^4$	13,000
(2) The average radiation field at 1ft from the surface of the unit shall not exceed 5 mr per hour.	$1·25 \times 10^4$	15,000
(3) The average field to the major portion of the operator's body shall not exceed 10 mr per hour. It is assumed that the field at 1ft from the surface of the unit is that received by the major portion of the body.	$2·5 \times 10^4$	29,000

Metals and Controls Corporation

The current activities of private American firms in the field of manufacturing fuel elements and other reactor components were well illustrated by the display of the Nuclear Products Division of the Metals and Controls Corporation, of Attleboro, Massachusetts. That company made history in 1952 by constructing a privately-owned production facility for the manufacture of fuel elements. This was the first time that production quantities of uranium-235 had been fabricated outside of A.E.C. facilities.

A wealth of nuclear material and fuel element manufacturing experience has been acquired. High quality fuel elements have been produced in wire, plate, tube, foil, rod, and disc forms. Core structural components are also produced, and nuclear research and development projects are a continuing activity. As a result of this experience, the Nuclear Products Division is now a well-qualified source of supply for a variety of nuclear fuel forms in quantities ranging from single elements to complete cores. Among the many reactors employing the firm's products are the Thermal Test Reactor at the Knolls Atomic Power Laboratory, the Battelle Memorial Institute Research Reactor, submarine reactor prototypes and naval propulsion units.

To meet the varied requirements of scientists and engineers exploring the nucleus, fissionable materials are produced in wire, rod, tube, disc and plate forms for experimental uses. Included in the many materials that have been shaped are uranium, its oxides and alloys, thorium and thorium oxide, zirconium, aluminium, hafnium and stainless steel. Fuel elements fabricated in rod, tube, plate and other forms have been installed in over twenty reactors and critical assemblies.

A particularly interesting development exhibited was the so-called "Island PT" fuel strip. These strips are thin sheets of uranium or uranium alloy clad with corrosion resistant materials through a newly developed solid-phase bonding process. (The cold bonding method is fully described in the U.S. Patents 2,691,815; 2,713,011; 2,700,907; 2,709,142; 2,753,623.) The complete surrounding of the fuel core by the cladding material is achieved by an unusually large degree of plastic deformation; i.e., without recess machining or picture framing. The strips are adaptable for use in critical assemblies, since they can be formed into a variety of configurations as well as being resistant to corrosion and high temperatures. The production of "Island PT" elements takes place in three distinct stages. In the first stage the metal strips are carefully cleaned to remove all surface contamination. Soon after the cleaning stage the components are guided into a rolling mill for a heavy reduction pass, resulting in a "green" bond. In the third bonding step the rolled strip is sintered to convert the "green" bond to a final bond of great strength, then precision rolled to finished thickness, X-rayed to locate the core outline, trimmed or stamped out to final dimensions, autoclave tested and finally inspected.

These fuel strips are well suited for critical assemblies and reactor experiments requiring a corrosion resistant, uranium containing element. The particular advantages of this element are: (1) Low cost, even in small quantities, due to the elimination of expensive machining, packaging and evacuation associated with hot roll bonding. In large quantities there are further savings due to the adaptability of process to semi-automation. (2) Superior handling qualities compared to bare foil, plastic-coated foil and ceramic-clad fuel elements. (3) Superior performance at high temperature and thermal cycling. (4) Completely bonded cladding and absence of thick "hot-bonding" diffusion boundary.

Beryllium Corporation

Various examples of the nuclear applications of beryllium metal were displayed by the Beryllium Corporation, of Reading, Pennsylvania. The opening of the Nuclear Division of the firm in July, 1957, marked the completion of the first privately financed facility for the quantity production of beryllium metal. Initially, production will be concentrated on nuclear grade beryllium metal for use in reactors.

The largest presently known and proven application of beryllium metal is its use as a moderator and reflector material in nuclear reactors. Beryllium is an outstanding reflecting material due to its low neutron absorption cross section. This means that when a neutron from the fissioning fuel strikes a beryllium nucleus, it is more likely to rebound than to be absorbed. If a reactor core is surrounded by a beryllium reflector, escaping neutrons will tend to bounce back into the arena of fission. Low atomic weight together with low neutron absorption are reasons for the exceptionally good performance of beryllium as a moderator. In some reactors, the moderator envelops the fuel elements; in others, fuel and moderator are actually mixed. In either design, a fast moving liberated neutron will enter the retarding medium. Unless the moderator has a low neutron absorption cross section, too many neutrons will be lost by assimilation in non-fissionable material.

In any comparison of materials based upon moderating qualities, beryllium and beryllium oxide both rank high. Beryllium has the further distinction of being the only metallic element in the list of suitable moderators. Being light, and at the same time a highly efficient moderator, the metal has particular value where it is desirable to save space and weight. To date, the relatively high cost of nuclear grade metal has limited the use of beryllium in nuclear energy projects. Other materials, such as graphite and heavy water, have figured more prominently in existing reactors. Even so, beryllium has not been neglected. It is used in the Materials Testing Reactor (MTR) and in the Submarine Intermediate Reactor (SIR) aboard the U.S.S. "Sea Wolf." Beryllium oxide serves as a reflecting material in the Bulk Shielding Facility (Swimming Pool), the Low Power Water Boiler (LOPO) and the High Power Water Boiler (HYPO).

Beryllium metal is now commercially available as technical grade and high purity grade beads, and as nuclear grade cast billets and powder. Limited quantities of shapes produced by powdered metal techniques utilising nuclear grade powder are also available. Recently, hot pressed shapes of nuclear grade beryllium became available in sizes up to approximately 12in diameter by 24in long. Laboratory quantities of extrusions and flat rolled products have been produced for research purposes. However, much additional work is necessary in order to perfect fabricating techniques and establish minimum mechanical property values.

(*To be continued*)

Personal and Business

Appointments

MR. A. M. GODLEY has been appointed manager of export sales of Auto Diesels, Ltd.

MR. CLEMENT P. COLLIER has been appointed production controller of Small and Parkes, Ltd.

MR. A. E. MORTON has been appointed home sales manager and publicity manager of Mathew Brothers.

MR. A. D. JENKINS, A.M.I.E.E., has been appointed divisional chief engineer, Smiths Industrial Instruments, Ltd.

THE INSTITUTE OF METALS has announced that Marshal of the Royal Air Force Lord Tedder, has been elected president.

MR. R. S. LOCK has been appointed secretary of A. Reyrolle and Co., Ltd., in succession to Mr. G. J. Dodgson who is to retire on May 31.

MR. S. E. CLOTWORTHY has been elected president of the Aluminium Development Association for 1958–59. Dr. Maurice Cook has been elected vice-president.

INTERNATIONAL HARVESTER COMPANY OF GREAT BRITAIN, Ltd., announces that Mr. Brooks McCormick has been elected a director of the International Harvester Company.

BRITISH ROAD SERVICES announces that Mr. I. F. C. Beswick, has been appointed divisional engineer, north western division, British Road Services, in succession to Mr. W. H. Smith.

MR. H. C. JOHNSON, general manager Eastern Region, British Railways, has been appointed a member of the British Railways Productivity Council in succession to the late Mr. C. K. Bird.

SCAFFOLDING (GREAT BRITAIN), Ltd., has announced the appointment of Mr. J. Scowen as manager of its Newcastle branch. The telephone number of the branch has been changed to Newcastle 65-6462.

HUNTINGTON, HEBERLEIN AND CO., Ltd., has announced that Mr. A. T. Rogers, chief engineer, and Mr. R. F. Jennings, in charge of the sinter section, have been appointed technical directors.

MR. L. E. WILLSON has been appointed assistant sales manager of the Skefko Ball Bearing Company, Ltd., Luton. He has been succeeded as manager of the company's Southampton office by Mr. G. T. Boden.

MR. H. H. GOTT, A.M.I.Mech.E., chief engineer, reactor design, in the industrial power branch of the Atomic Energy Authority, has been appointed nuclear plant design engineer of the Central Electricity Generating Board.

THE NATIONAL INSPECTION COUNCIL FOR ELECTRICAL INSTALLATION CONTRACTING has appointed Mr. M. J. Pryor as its inspecting engineer for the South Wales area, Monmouthshire, Herefordshire and part of Gloucestershire.

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION has announced that Mr. Richard Nugent, M.P., and Mr. Airey Neave, M.P., joint parliamentary secretaries to the ministry, have appointed Mr. R. W. Elliott as their parliamentary private secretary.

WILLIAM JESSOP AND SONS, Ltd., and its associated company, J. J. SAVILLE AND CO., Ltd., have announced the appointment of Mr. D. Milne as secretary in succession to the late Mr. F. Briggs. Mr. J. V. Gregory has been appointed assistant secretary.

ENGLISH ABRASIVES CORPORATION, Ltd., states that it has established a central administrative office at Marsh Lane, Tottenham, London, N.17, and that all correspondence for its subsidiary companies, Thos. Goldsworthy and Sons, Ltd., Helvetia Abrasives Company, Ltd., and London Abrasives, Ltd., should in future be directed to this address. Mr. H. L. Steer is responsible for home sales activities and Mr. V. L. Stevens is responsible for export sales activities. Mr. H. Gaunt is secretary of the Corporation.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., announces the following appointments: Mr. F. C. Barford, M.I.E.E., has been appointed manager of the small industrial machines department, Blackheath, Birmingham, and has been succeeded as manager, Birmingham district, by Mr. K. J. Clarke, A.M.I.E.E. Mr. W. J. Wilson, A.M.I.E.E., has been appointed to succeed Mr. Clarke as manager, Sheffield district. Mr. J. N. Griffiths has been appointed manager, Leeds district, in succession to Mr. Wilson.

EXPANDITE Ltd., has announced the following appointments: Mr. T. Pooley has been appointed deputy managing director; Mr. E. L. Townsend has been appointed director in charge of overseas developments; Mr. J. M. Robb, manager of the overseas division, has been appointed general manager Expandite (Australia) (Pty.), Ltd., and will be taking up the post in Australia about July; Mr. J. H. Humphries has been appointed area manager, Scotland, and Mr. A. W. Moignard has been appointed assistant area manager for south-east England.

Business Announcements

LORD DUDLEY G. GORDON, chairman of the Hadfield Group of companies, is touring Canada and North America.

STERLING WHEELBARROW COMPANY announces that its name has been changed to Sterling National Industries Inc., Milwaukee 14, Wisconsin, U.S.A.

DRUMMOND ASQUITH (SALES), Ltd., states that the address of its Glasgow branch office is 40, West Nile Street, Glasgow (telephone, Central 0922).

W. T. HENLEY'S TELEGRAPH WORKS COMPANY, Ltd., states that its engineering sales department has moved to 59–62, High Holborn, London, W.C.1.

FONADEK (BRANSEN), Ltd., Harborne, Birmingham, has moved its London offices from 69, Wigmore Street, W.1, to 442, Chiswick High Road, W.4 (telephone, Chiswick 8561).

JACKSON AND BRADWELL, Ltd., has announced that it will move from 32, Paradise Street, Birmingham, 1, to Grove House, Sutton New Road, Birmingham, 23 (telephone, Erdington 7411-2), on May 10.

STEIN AND ATKINSON, Ltd., states that it is to cease the manufacture of rotary and end tilting rotary melting furnaces and that its drawings and designs have been acquired by the Monometer Manufacturing Company, Ltd.

EKCO ELECTRONICS, Ltd., and GEORGE KENT, Ltd., state that they are now offering their joint services for the contracting, engineering and manufacture of over-all instrumentation schemes for both power and research reactors.

THOMAS WHITE AND SONS, Ltd., Laighpark, Paisley, Scotland, announces that it has acquired the manufacturing rights for the knife and shear blade automatic grinding machines formerly marketed by Luke and Spencer Ltd., Altrincham, Cheshire.

SULZER BROS. (LONDON), Ltd., 31, Bedford Square, London, W.C.1, states that its telephone number has been changed to Museum 7890. The address of its heating and ventilating division has been changed to 12, Dyott Street, London, W.C.1 (telephone Covent Garden 3381).

NEWTON CHAMBERS AND CO., Ltd., Thorncliffe near Sheffield, has entered into a licence agreement with the Struthers Wells Corporation, Warren, Pennsylvania, U.S.A., for the manufacture of Struthers Wells equipment designed for industrial heating at high temperatures.

CLARKE, CHAPMAN AND CO., Ltd., announces that it is to resume the production of electric level luffing ship's deck cranes and that the cranes can either revolve round a fixed centre post, be fixed to a base plate in the deck, or have a travelling carriage to provide athwartship movement.

FERRANTI, Ltd., announces that, with effect from June 1, it will relinquish the manufacture, marketing and servicing of some models of domestic heating appliances, and that in future these appliances will be manufactured by E. K. Cole, Ltd. These appliances include the "Firestreak" wall fire, "Mistral" convector, "Flamera" coal fire, and "Victor" lightweight portable and bathroom fires.

MARSHALL SONS AND CO., Ltd., Britannia Works, Gainsborough, announces that it has concluded a licence agreement with the Cleaver-Brooks Company of Milwaukee, Wisconsin, U.S.A., to manufacture packaged steam and hot water generators. The agreement is for the manufacture of a range of oil burning fire tube units, of four pass design, from 500 lb to 20,000 lb of steam per hour capacity at pressures up to 250 lb per square inch gauge.

RESEARCH AND CONTROL INSTRUMENTS, Ltd., Instrument House, 207, King's Cross Road, London, W.C.1 (telephone Terminus 8444), announces that it has commenced operations on May 1, becoming the sole distributor in the United Kingdom for the electronic instruments and scientific equipment hitherto marketed by Philips Electrical, Ltd. (Research and Control Instruments Division). The new company is responsible for the maintenance of existing Philips equipment and its field staff is supported from a Service Department and Stores located at 49, Temperley Road, Balham, London, S.W.12 (telephone Battersea 9166 and 9197). In addition, it will distribute in Great Britain the industrial X-ray equipment manufactured by C. H. F. Müller A.G., Hamburg, and X-ray diffraction and spectographic equipment made by Norelco (U.S.A.). Research and Control Instruments, Ltd., has been appointed sole distributor responsible for the sale and servicing of Müller electronic measuring instruments and electro-chemical apparatus in the United Kingdom, and will also handle electronic instruments made by Elektro Spezial A.G., of Hamburg. Mr. R. H. Cooke has been appointed a director and general manager of Research and Control Instruments, Ltd.

Contracts

J. FENWICK AND CO., Pty., Ltd., Sydney, Australia, has placed an order with Seawork, Ltd., for a tug of Hydroconic design, to be built by T. Mitchison, Ltd., Gateshead-on-Tyne. Propulsion will be by two "JLSGMR.6" Mirrlees diesel engines driving through a Modern Wheel Drive reduction gearbox.

Miscellanea

ANTIBIOTIC PLANT.—A pharmaceutical plant occupying a 16-acre site bordering the Gosport-Fareham road, has been built by Cyanamid of Great Britain, Ltd., for its Lederle Laboratories Division. The single-storey factory has a floor area of 67,000 square feet and two 100ft clear spans, and has been designed and developed by C.A.I. (Industrial Developments), Ltd.

REFRIGERATION JUBILEE.—The April issue of *Modern Refrigeration and Air Control News* is a diamond jubilee number celebrating the completion of sixty years of continuous publication. The volume, in addition to the usual articles, contains messages from the leaders of the refrigeration industry and a number of articles dealing with progress in refrigeration, while another section consists of reports descriptive of the progress made by individual firms within the machinery and insulation industries.

BRITISH ENGINEERS ASSOCIATION.—The British Engineers Association held its annual luncheon, in London, on Thursday of last week, with Sir Edward Thompson, the president, in the chair. The principal guest was Viscount Chandos who spoke after the luncheon about some of the problems of the proposed European Free Trade Area. One of the important considerations, Viscount Chandos said, was whether a member-country would have the right to take steps to protect its currency at a given exchange rate. It would be impossible, he asserted, to have free trade without free exchange.

SULPHUR BURNER.—We are informed by the Kestner Evaporator and Engineering Company, Ltd., that it has developed the Kestner spray type sulphur burner, which consists essentially of a specially designed atomiser and combustion chamber, generating the sulphur dioxide at high concentration. It is claimed that the new burner has a high turn-down ratio, since the sulphur feed rate may be varied over a wide range by manipulating a feed control valve. burner gas containing up to 18 per cent sulphur dioxide by volume may be readily obtained. The unit may be operated under any back pressure normally required.

INSTITUTION OF STRUCTURAL ENGINEERS.—At the recent annual dinner of the Institution of Structural Engineers, the president, Professor Sir Alfred Pugsley, announced that H.R.H. Prince Philip, Duke of Edinburgh, had been elected to honorary membership. The president announced also the Institution's decision to establish a "Maitland lecture" as an annual competition for members and associate members. The lecture may deal with research, design or construction in the field of structural engineering with special reference to new developments. The award for the lecture will be the Maitland silver medal and a premium of £100. This lecture is being initiated to signify appreciation of the work of Major R. F. Maitland who has been secretary of the Institution since 1930.

INSTITUTE OF FUEL.—The annual luncheon of the Institute of Fuel was held on Thursday, April 24, at the Connaught Rooms, Great Queen Street, Kingsway, London, W.C.2, and was attended by over 700 members and guests. The president proposed the toast of "The Guests" and presented the first Bonnington Wheeler medal and prize to Mr. A. M. Freedman for his paper "Experience with the Humidification of Combustion Air to Prevent Boiler Fouling." Mr. H. McNeil also presented Lord McGowan with a past-president's badge, and made mention of the establishment of a memorial award, in commemoration of the late Dr. G. E. Foxwell, which would be used for educational purposes. The president also had a word to say concerning the growth of the Institute, the formation of a group in the Argentine and a South-East London section. Mr. W. L. Fraser replied and made the subject of his remarks the activities of the City, including banks, insurance, shipping and commodity markets.

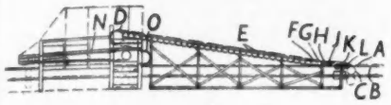
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

MINING ENGINEERING

792,867. November 26, 1954.—ENDLESS CONVEYOR SYSTEMS, Coal Industry (Patents), Ltd., Hobart House, London, S.W.1. (*Inventor: Colin Rudge.*)

The invention relates to endless conveyor systems, including cable-belt conveyors of the kind wherein the belt is supported on cables or wire ropes running parallel to the belt. Its object is to provide means for delivering material relatively smoothly and gently on to the belt of the conveyor. Referring to the



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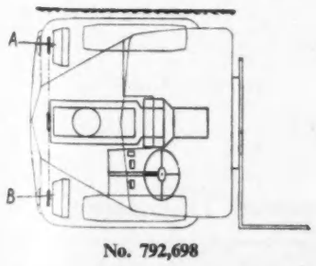
drawing, a conveyor belt *A* is supported by shoes on one or more wire ropes *B*, the normal run of the belt and ropes being horizontal. The rope passes over a drum *C* where the belt is taken off the ropes and raised through an incline of an angle of 8 deg. or 9 deg. to a high level, where it runs on a drum *D*. During its upward movement the belt is unsupported by the rope, but alternative support is provided by a series of rollers *E* and *F*, *G* and *H*, &c., which are of progressively decreasing diameter to the smallest roller *J*. The rollers *E* and *F* are dimensioned and designed so that they act as a support for the shoes on each side of the belt. To provide additional support for the belt two additional rollers *K* and *L* are provided, which are arranged to bear directly against the inner part of the belt shoe on each side of belt. As the belt passes over drum *D* the material is tipped off on to a scraper-chain conveyor *N* below and parallel to the belt and this can also receive material from one or more auxiliary transverse conveyors. The scraper-conveyor delivers the material which it receives back on to the belt *A*, which is led from drum *D* round another drum *O* back into a horizontal position at the level corresponding to the original level shown at the right-hand side of the drawing, so as to pass beneath the scraper conveyor and receive material from the delivery end of it. The vertical distance between the left-hand end of the scraper-conveyor *N* and the belt *A* is very small, so that in this way all the material, both from the main belt *A* and from the auxiliary transverse conveyor or conveyors, is delivered relatively gently and without undue disturbance on to the belt *A*.—*April* 2, 1958.

ROAD TRANSPORT

792,698. February 1, 1956.—ENGINE COOLING ARRANGEMENTS IN MOTOR VEHICLES, The Daimler-Benz Aktiengesellschaft, Stuttgart-Untertürkheim, Germany.

This invention concerns improvements relating to the cooling arrangements of engines in motor vehicles, particularly commercial vehicles. An object of the invention is to achieve effective cooling in conjunction with favourable utilisation of space. The motor



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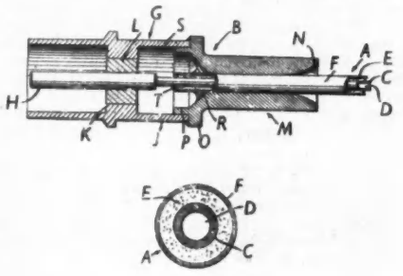
vehicle according to the invention has a liquid-cooled engine arranged at the front in advance of the driver's seat and has radiators *A* and *B*, one on each side of the front portion of the engine with their cooling surfaces extending transversely of the direction of travel. The two radiators each have a blower or fan disposed in front of them. Preferably, pressure blowers are used, but fans may be employed. The blowers or fans may be driven from the engine through a common belt or chain drive.—*April* 2, 1958.

ELECTRICAL ENGINEERING

791,786. February 28, 1956.—HEAT DETECTING ELECTRIC CABLE, Specialties Development Corporation, 675, Main Street, Belleville, 9, New Jersey, U.S.A.

The invention relates to a heat and flame-detecting cable in which electrically conductive elements are separated by a mass of material which acts as an insulator at a given temperature and becomes electrically conductive at another temperature. Referring to the drawing, there is shown a heat or flame-detecting cable *A* and an end connector *B* for the cable. The cable comprises an electrically conductive uninsulated bendable tube *C* having a bore *D*, an annular mass *E* of ceramic-like, thermistor material surrounding the tube *C* and an electrically conductive bendable tube or sheeth *F* surrounding the mass *E*. The tubes *C* and *F* are coaxial and substantially co-extensive in length and the mass closely engages the same, and acts as an insulator at a given temperature and is electrically conductive at another temperature. This material may be of the type disclosed in Specification No. 705,288. The connector *B* generally comprises an electrically conductive tubular body *G* in connection with the tube *F*, and an electrically conductive pin or rod *H* extending axially within



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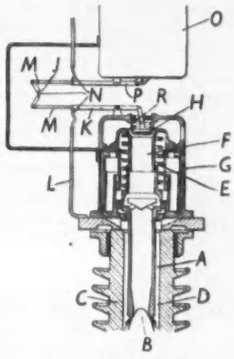
the body and centrally located therein, but insulated therefrom and in electrical connection with the tube *C*. The cable and connector assembly in this manner provide two conductors across which an electrical connection can be made when the material *E* becomes conductive to establish a circuit. The tubular body *G* comprises a metallic sleeve *J* formed with an apertured wall *K* at about the middle thereof wherein a mass of material *L* is positioned, such as electrically non-conductive glass, which supports the pin *H* and, if desired, forms a hermetic seal between the pin and the wall while insulating the pin therefrom; and a metallic closure *M* having a tubular section *N* through which the cable *A* extends and having a flange *O* and a collar *P* fitting into the sleeve *J* and hermetically sealed thereto by soldering, welding or brazing the flange to the end of the sleeve. Solder or brazing material *R* electrically and structurally connects the tube *F* and the closure *M* and, if desired, forms a hermetic seal between these elements. The tube *C* is electrically connected to the pin *H*. In this manner, an airtight chamber *S* may be provided wherein the end of the cable *A* is located and is sealed against moisture getting into the material *E* within the tube *F*. If desired, this end of the tube may be further sealed by a glass bead *T* through which the tube *C* extends. In accordance with the invention, the zone affected by changes in temperature to render the same conductive is a relatively thin-walled cylindrical mass close to the inner wall of the sheath tube *F*, whereby heat flow is rapidly effected through the zone to be rendered conductive and produce a more rapid response than heretofore where penetration to the centre of the mass was required. Also, the zone to be rendered conductive is uniform circumferentially, whereby a response in about the same time can be produced regardless of the angular application of the temperature changing source.—*March* 12, 1958.

786,607. January 27, 1956.—AIR BLAST ELECTRIC CIRCUIT BREAKERS, Aktiengesellschaft Brown, Boveri and Cie., Baden, Switzerland.

With gas or air blast circuit breakers the pressure gas—for instance, air—which operates the breaker and is supplied from an external pressure air container and an air compression plant, is generally independent of the current which is to be interrupted. It is thus necessary, even with small currents which only require small amounts of air to use the entire quantity of air provided for the maximum rupturing capacity. In some cases this results in an unnecessarily large plant for producing the pressure air and causes the mechanical parts of the breaker to be stressed more than is necessary. Furthermore, there is also the possibility that with small currents the arc may be interrupted before the zero point is reached and this causes unnecessary over-voltages. The object of the invention is to provide a device which controls in a simple manner the pressure air flow directly by means of the current that is to be interrupted. Referring to the drawing, the interrupter consists of movable hollow contact *A* and stationary contact *B*. It is located in hollow insulator *C*, the interior *D* of which represents the switch chamber. Pressure air passes in the direction indicated by the



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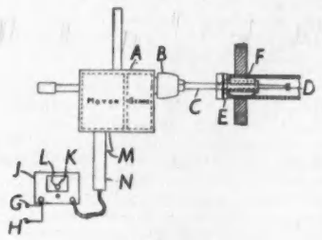
arrow to the contacts *A* and *B*, where, after the opening movement has commenced—this being effected by the action of the pressure air against the spring *E*—the arc is extinguished. The pressure air passes through the inside of contact *A* and then through space *F* in metallic chamber *G* mounted on insulator *C*, whereupon it reaches exhaust valve *H*. The strength of the air flow depends upon the extent of the valve opening. The valve opening is controlled by a conductor loop *J* and linkage *K*. The conductor loop is located in the lead *L* to the contacts *A* and *B*. It consists of two rigid members *M*, which, by means of flexible pieces *N* are connected together and to the lead *L* to the contacts. The magnitude of the current flowing through the conductor loop determines the extent of the opening of the exhaust valve *H*. In the drawing a second interruptor *O* is indicated, the exhaust valve of which is controlled by the same conductor loop *J* and rodding. Spring *R* serves to close the exhaust valve *H*. Modified constructional forms are also shown in the specification.—*November* 20, 1957.

791,815. April 27, 1955.—ELECTRICALLY DRIVEN TUBE EXPANDER TOOLS, Metropolitan-Vickers Electrical Company, Ltd., St. Paul's Corner, 1–3, St. Paul's Churchyard, London, E.C.4. (*Inventor: Alfred Alexander Gregory.*)

The invention relates to tube expander tools having rollers pressed by a conical mandrel against the inner wall of the end of the tube and driven by an electric motor. It aims at an improved means for automatically stopping and reversing the motor in dependence upon a predetermined motor torque. As can be seen from the drawing, the mechanical part of



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the tool comprises a portable electric motor and is accommodated in a casing *A*, together with a reduction gear for driving via a chuck *B* a tapered shaft *C* which carries the expander head and at its outer end a stop nut *D*. The expander head includes a stop ring *E* and an arrangement of tapered rollers *F*, and is axially movable along the shaft *C* between the chuck and stop nut *D*. The motor is connected to a power current supply by terminals *G* and *H* via a control box *J* which houses electric control elements, including a meter having a settable pointer *K*. The setting of this pointer determines the value at which automatic reversal of the motor is required and an indicating pointer *L* is provided to afford an indication of the electric quantity which is a measure of the motor torque, and therefore varies during operation of the expander. The start of the whole operation is controlled by a single switch having an actuating element *M* of trigger fashion protruding from a handle *N* of

the casing *A*. By means of the above described tool mechanical operations can be carried out in order to expand a tube end and secure it to a tube plate. First the expander head, comprising the tapered roller arrangement *F*, is pushed towards the lesser end of the shaft *C* until it abuts the stop nut *D*. The head is then inserted in the tube to be expanded until the stop ring *E* abuts the end of the tube. An axial pressure is applied and the trigger switch is pressed to start the motor which drives the tapered shaft. As the tapered shaft moves axially relative to the expander head, the effective diameter of the tapered roller arrangement increases, thereby causing expansion of the tube end. The increasing opposing torque causes an increase in the motor current, which is used to stop and reverse the motor automatically when the current, which is a measure of the torque, and, therefore, of the expansion achieved under given conditions, has reached a predetermined value. The manner in which this is effected by the automatic electric control of this invention, the circuit components required and their interconnection are described in the specification.—*March* 12, 1958.

Launches and Trial Trips

CLAN MATHESON, cargo liner; built by the Greenock Dockyard Company, Ltd., for the Clan Line Steamers, Ltd; length between perpendiculars 465ft, breadth moulded 65ft 6in, depth moulded 39ft 7½in, gross tonnage 7800, deadweight 9760 tons on 27ft 3in mean draught, service speed 16½ knots; twelve passengers, five holds, bale capacity 572,000 cubic feet, one 80-ton, two 40-ton, two 15-ton, four 7-ton, ten 5-ton and two 3-ton derricks, electric winches; three 220kW diesel-driven generators; Wallsend-Doxford diaphragm opposed-piston oil engine, six cylinders, 750mm diameter by 2500mm combined stroke, 7500 b.h.p. at 103 r.p.m.—Trial, December 17 and 18.

LONDON RESOLUTION, oil tanker; built by the Furness Shipbuilding Company, Ltd., for London and Overseas Freighters, Ltd.; length between perpendiculars 560ft, breadth moulded 80ft, depth moulded 42ft 3in, summer draught 32ft 4½in, deadweight 24,900 tons; twenty-seven oil compartments, cathodic protection in nine centre tanks, one cargo pump room, three 1000 tons per hour turbine-driven centrifugal cargo pumps, three 150 tons per hour vertical steam stripping pumps; two 325kW turbo-generators, one 100kW diesel-driven generator; one set of Richardsons Westgarth double-reduction geared turbines, 7300 s.h.p. at 100 propeller r.p.m., two Foster-Wheeler "D" boilers supply steam at 450 lb per square inch and 750 deg. Fah. Trial, December 18.

KING GEORGE, cargo ship; built at Belfast by Harland and Wolff, Ltd., for the King Line, Ltd.; length between perpendiculars 435ft, breadth moulded 59ft, depth to shelter deck 39ft 9in, gross tonnage 6000, deadweight 9500 tons; two complete steel decks, four holds and one deep tank, one 50-ton, one 25-ton, four 10-ton and six 5-ton derricks; electric winches; three 125kW diesel-driven generators; Harland-B. and W. single-acting, four-stroke diesel engine, six cylinders, 740mm diameter by 1500mm stroke, 115 r.p.m. Trial, December 19.

CHICANOA, banana cargo and passenger liner; built by Alexander Stephen and Sons, Ltd., for Elders and Fyffes, Ltd.; length between perpendiculars 390ft, breadth moulded 56ft 6in, depth to upper deck 35ft; twelve passengers; four insulated holds, eight 5-ton derricks, electric winches; two 450kW geared turbo-generators, one 400kW diesel-driven generator; one set of two-casing, double-reduction geared turbines, supplied with steam at 500 lb per square inch and 790 deg. Fah. by two Babcock and Wilcox boilers. Launch, December 20.

ABEL TASMAN, cargo ship; built by Hall Russell and Co., Ltd., for H.C.S. Coasters Pty., Ltd., Melbourne; length between perpendiculars 290ft, breadth moulded 44ft 6in, depth moulded 22ft 3in, deadweight 3500 tons; two large holds, electric winches, derricks to lift 7½ tons; three 150kW diesel-driven generators; one five-cylinder, two-stroke, trunk-piston Sulzer diesel engine, 2000 b.h.p. at 155 r.p.m. Trial, December 23

BRITISH AVIATOR, oil tanker; built at Wallsend by Swan, Hunter and Wigham Richardson, Ltd., for the B.P. Tanker Company, Ltd.; length between perpendiculars 640ft, breadth moulded 86ft, depth moulded 49ft 3in, deadweight 34,500 tons on 37ft draught, service speed 15½ knots; thirty cargo oil tanks, one cargo pump room, three 850 tons per hour turbine-driven centrifugal pumps, two vertical steam-driven stripping pumps; two 600kW turbo-alternators, one 150kW diesel-driven alternator; one set of Wallsend Slipway two-casing double-reduction geared turbines, 15,500 maximum s.h.p. at 108 propeller r.p.m., steam supplied at 600 lb per square inch and 850 deg. Fah. by two Babcock and Wilcox "Selectable Superheat" boilers. Launch, December 23.

LOCH LOYAL, cargo liner; built at Belfast by Harland and Wolff, Ltd., for the Royal Mail Lines, Ltd.; length overall 503ft, breadth moulded 68ft, depth moulded to shelter deck 41ft, gross tonnage 11,000; twelve passengers; two steel decks, five holds, one 30-ton, six 10-ton and fourteen 5-ton derricks, electric winches, "Drihold" ventilation system; four 300kW diesel-driven generators; Harland and Wolff single-acting, two-cycle, opposed-piston engine, seven cylinders, 750mm diameter by 2000mm combined stroke, 110 r.p.m. Trial, December 30.

CHIRRIPO, refrigerated banana cargo and passenger liner; built by Alexander Stephen and Sons, Ltd., for Elders and Fyffes, Ltd.; length between perpendiculars 390ft, breadth moulded 56ft 6in, depth 35ft; twelve passengers; fourteen insulated cargo spaces, eight cooler rooms; two eight-cylinder "Arcton 6" compressors, eight 5-ton derricks, two 450kW geared turbo-generators, one 400kW diesel-driven generator; one set of two-casing, double-reduction geared turbines supplied with steam at 560 lb per square inch and 790 deg. Fah. by two Babcock and Wilcox sectional-header, single-pass boilers. Trial, December.

ESMERALDA, oil tanker; built by the Chantiers de l'Atlantique for the Compagnie Auxiliaire de Navigation; length between perpendiculars 685ft 9in, breadth moulded 97ft 5½in, depth 49ft 8½in, loaded draught 37ft 1in, deadweight 42,000 tons, displacement 56,400 tons, speed 16·7 knots; three 1350 tons per hour turbine-driven centrifugal cargo pumps, three stripping pumps; one set of C.E.M.-Parsons geared turbines, 17,250 normal s.h.p. at 100 propeller r.p.m., steam supplied at 640 lb per square inch and 840 deg. Fah. by two "P.41" Penhöet boilers. Trial, December.

HOEGH FORUM, oil tanker; built by the Ateliers et Chantiers de France for Leif Hoegh, Norway; length between perpendiculars 639ft 9in, breadth moulded 86ft, depth 46ft 7in, deadweight 33,274 tons, trial speed 15·8 knots; Burmeister and Wain diesel engine, 12,500 b.h.p. at 115 r.p.m. Trial, December.

TALASSA, cargo ship; built by the Forges et Chantiers de la Mediterranée for the Compagnie Maritime des Chargeurs Reunis; length between perpendiculars 433ft 1in, breadth moulded 61ft, depth to shelter deck 36ft, draught 24ft 1½in, loaded service speed 16 knots, one 50-ton, one 25-ton and eighteen 5-ton derricks; one Sulzer Mark 9.SD.72 Sulzer diesel engine, 6300 b.h.p. Trial, December.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, May 2.—BRISTOL AND WEST OF ENGLAND BRANCH: Grand Hotel, Broad Street, Bristol, "Industrial Electronics," 8 p.m. ★ LIVERPOOL BRANCH: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, "The Television Receiver," J. W. Driscoll, 7.30 p.m.

Mon., May 5.—LEEDS BRANCH: Great Northern Hotel, Leeds, "Silicones," R. Nattrass, 7.30 p.m. ★ NORTH EAST LONDON BRANCH: Angel Hotel, Ilford, "The Work of the Public Health Department," I. Gordon, 8 p.m. ★ SHEFFIELD BRANCH: Royal Victoria Station Hotel, Sheffield, "Application of Flameproof Electrical Equipment," 7.30 p.m.

Tues., May 6.—OXFORD, READING AND DISTRICTS BRANCH: Agricultural Hall, 121, Oxford Road, Reading, "Electrostatic Precipitation," 7.15 p.m.

Wed., May 7.—GLASGOW BRANCH: Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2, Annual General Meeting, 7.30 p.m. ★ MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, "Earth Leakage Protection of Electrical Installations," J. A. Robbins, 7 p.m. ★ PRESTON BRANCH: R.A.F.A. Club, East View, Preston, "Outdoor Illumination," H. Carpenter, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Sun. to Wed., May 11–14.—Grand Hotel, Eastbourne, Summer Meeting. Papers to be delivered at the Winter Gardens, Eastbourne.

INCORPORATED PLANT ENGINEERS

Tues., May 6.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, "What Management Requires of a Plant Engineer," W. J. Worsdell, 7 p.m. ★ PETERBOROUGH BRANCH: White Lion Hotel, Church Street, Peterborough, "Engineering Problems in the Beet Sugar Industry," K. Hample, 7.30 p.m.

Wed., May 7.—SOUTHERN BRANCH: Polygon Hotel, Southampton, "The Generation of Power from Atomic Energy," H. R. M. Hyder, 7.30 p.m.

Thurs., May 8.—GLASGOW BRANCH: Scottish Building Centre, 425/427, Sauchiehall Street, Glasgow, "Oil Firing as Applied to Steam Raising Plant," A. W. Rooney, 7.15 p.m.

Mon., May 12.—MERSEYSIDE AND N. WALES BRANCH: The Blossoms, Chester, "Heat Exchangers," Mr. Faunbern, 7.15 p.m.

INSTITUTE OF FUEL

Wed., May 7.—LONDON BRANCH: Institution of Civil Engineers, Great George Street, London, S.W.1, "Improved Sampling Equipment for Solids in Flue Gases," P. G. W. Hawksley, S. Badzioch and J. H. Blackett, 5.30 p.m.

INSTITUTE OF PETROLEUM

Wed., May 7.—61, New Cavendish Street, London, W.1, "Recent Developments in Refining," W. J. Newby, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., May 6.—Great George Street, Westminster, London, S.W.1, "Design and Performance of the Sasumua Dam," K. Terzaghi, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., May 5.—SOUTH MIDLAND CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "Electric Control of Stage and Television Lighting," F. P. Bentham, 6 p.m. ★ NORTH STAFFORDSHIRE SUB-CENTRE: Swan Hotel, Stafford, Annual General Meeting; "The Development of Variable Speed High-Power Drives for Large Wind Tunnels," and "A Variable-Frequency Power Installation for Large Wind-Tunnel Drives," P. McKearney, L. S. Drake and E. G. Mallalieu; "Speed Control of Large Wind Tunnels with Particular Reference to the R.A.E. 8ft by 8ft High-Speed Wind Tunnel," L. S. Drake, J. A. Fox and G. H. A. Gunnell; "Automatic Setting of the Flexible Walls of a Large Wind Tunnel," T. Barnes and C. R. Dunham, 7 p.m.

Tues., May 6.—MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, "Some Case Histories of Business Computers in the U.S.A.," A. T. Starr, 5.30 p.m. ★ NORTH MIDLAND CENTRE: C.E.A. Offices, Yorkshire Division, 1, Whitehall Road, Leeds, Annual General Meeting, 6.30 p.m. NORTH-WESTERN CENTRE: Engineers' Club, 17, Albert Square, Manchester, Annual General Meeting; "Supply-Voltage and Current Variations Produced by a 60-ton, 3-phase Electric Arc Furnace," B. C. Robinson and A. I. Winder, 6.15 p.m. ★ NORTHERN IRELAND CENTRE: Civil Engineering Department, David Keir Building, Queen's University, Belfast, Annual General Meeting, 6.30 p.m.

Wed., May 7.—LONDON GRADUATE AND STUDENT SECTION: Visit to London Airport (Communications Equipment), 2 p.m. ★ NORTH LANCASHIRE SUB-CENTRE: N.W.E.B. Demonstration Theatre, Friargate, Preston, Annual General Meeting; "Electrical Floor Warming," J. W. Moule and W. M. Stevenson, 7.15 p.m. ★ SOUTH-WEST SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, Annual General Meeting, 7 p.m.

Thurs., May 8.—UTILIZATION SECTION: Savoy Place, London, W.C.2, "Artificial Fibres," P. T. Standring, 5.30 p.m. ★ NORTH SCOTLAND SUB-CENTRE: Electrical Engineering Department, Queen's College, Dundee, Annual General Meeting, 7 p.m. ★ SOUTH WESTERN SUB-CENTRE: Electric Theatre, Union Street, Torquay, "Preventive Maintenance," P. L. Lutte and A. G. Milne, 3 p.m.

Fri., May 9.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "The Teaching of Applied Acoustics," opened by G. Mather, 6 p.m.

Mon., May 12.—LONDON GRADUATE AND STUDENT SECTION: Savoy Place, London, W.C.2, Annual General Meeting, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, May 2.—JAMES CLAYTON LECTURE: 1, Birdcage Walk, Westminster, London, S.W.1, "Large Pipeline Projects," A. C. Hartley, 6 p.m.

Thurs., May 8.—EAST MIDLANDS GRADUATES' SECTION: Technical College, Shakespeare Street, Nottingham, Annual General Meeting; Film Show, 7.15 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Mon., May 5.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, Annual General Meeting, "Automatic Data Processing Equipment—An Introduction to its Techniques and Applications," F. J. M. Laver, 5 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Wed., May 7.—WALES AND MONMOUTHSHIRE BRANCH: Machworth Hotel, Swansea, Annual General Meeting, 6.30 p.m.

INSTITUTION OF WORKS MANAGERS

Thurs., May 8.—PRESTON BRANCH: Council Chamber, Town Hall, Preston, Annual General Meeting, 7.30 p.m.

IRON AND STEEL INSTITUTE

Wed. and Thurs., May 7 and 8.—4, Grosvenor Gardens, London, S.W.1, Annual General Meeting: Wednesday, 2.45 p.m.; Thursday, 10 a.m.

JUNIOR INSTITUTION OF ENGINEERS

Wed., May 7.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Protective Relays," H. S. Lewis, 7 p.m.

PLASTICS INSTITUTE

Tues., May 6.—LONDON AND DISTRICT SECTION: Wellcome Building, 183–193, Euston Road, London, N.W.1, "Modern Ideas on Polymer Formation and Degradation," N. J. L. Megson, 6.30 p.m.

Wed., May 7.—YORKSHIRE SECTION: Prospect Hall, Cleckheaton, Yorks, Annual General Meeting, 7.15 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., May 5.—ORDINARY GENERAL MEETING: 12, Great George Street, Westminster, London, S.W.1, "Ten Years of Planning: Where Has It Got Us?" L. W. Lane, 5.45 p.m.

ROYAL SOCIETY OF ARTS

Wed., May 7.—John Adam Street, Adelphi, London, W.C.2, "British Trade and Commerce," No. 3, "With Western Europe," R. Falk, 2.30 p.m.

ROYAL STATISTICAL SOCIETY

Wed., May 7.—BIRMINGHAM INDUSTRIAL APPLICATIONS SECTION: Birmingham College of Technology, Gosta Green, Birmingham, One-day Conference on "Statistical Sampling in Industry," 9.45 a.m.

Advanced Engineering Courses

Production Planning and Control. UNIVERSITY OF BIRMINGHAM, INSTITUTE FOR ENGINEERING PRODUCTION, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. Residential executive course, 9.30 a.m. Monday, May 12, to 4 p.m. Friday, May 23. Fee fifty guineas.

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Radioactive Contamination of Water and Sewage. MECHANICAL LECTURE ROOM, FACULTY OF ENGINEERING, University College, Gower Street, London, W.C.1. Course of evening lectures, Mondays and Thursdays, 5 p.m. to 7 p.m. April 28 to May 15.

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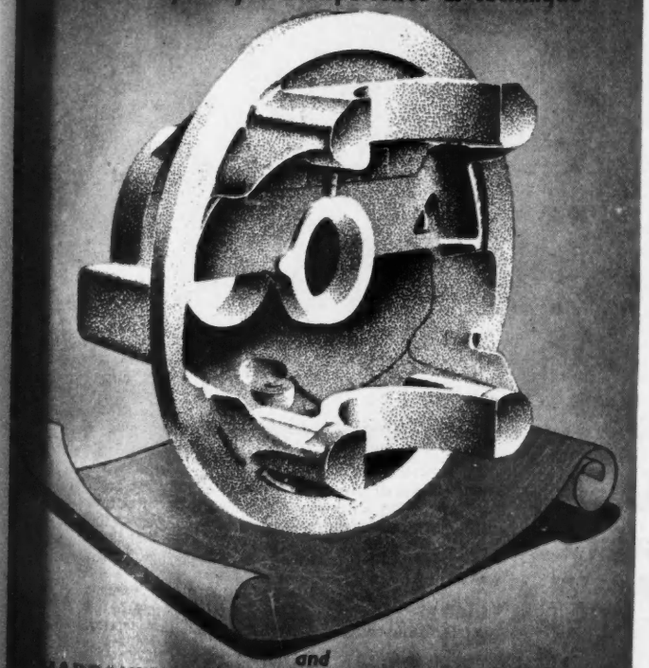

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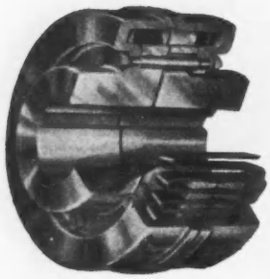

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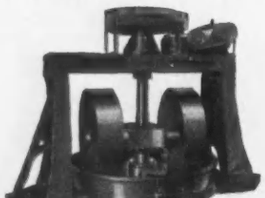

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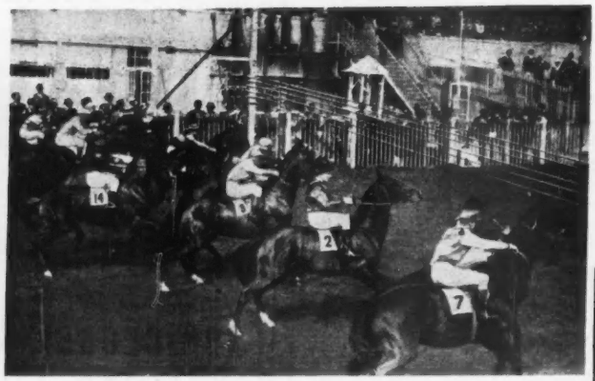

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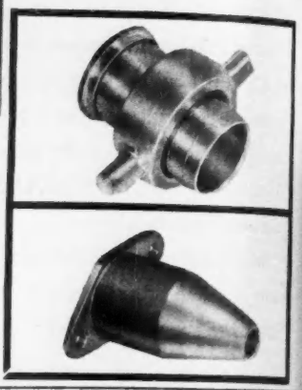

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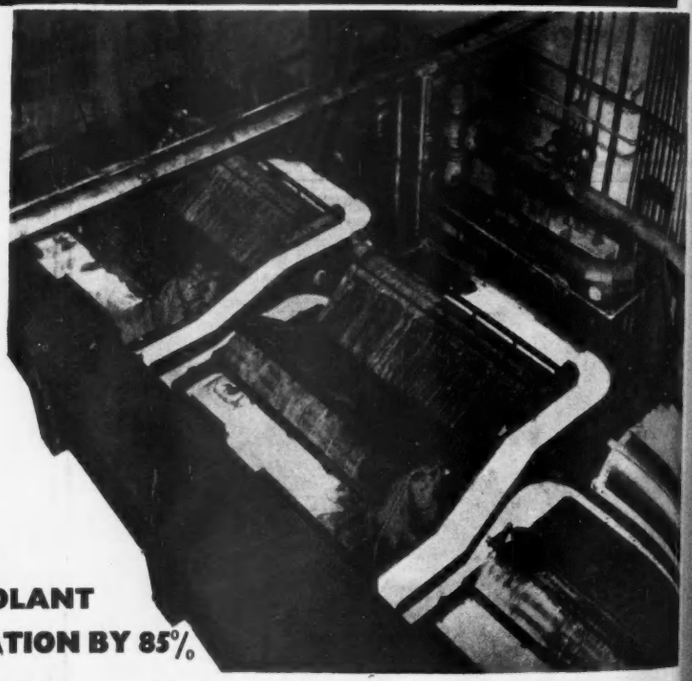

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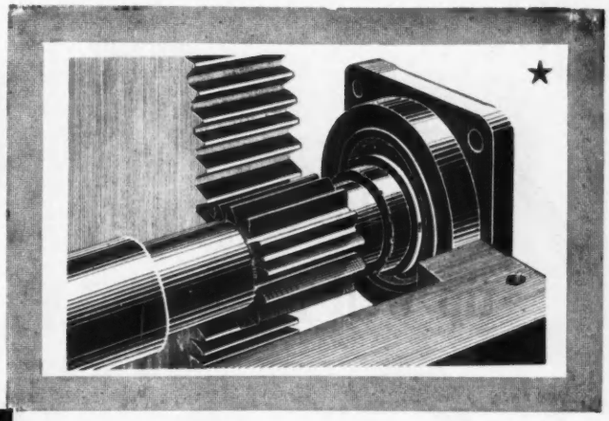

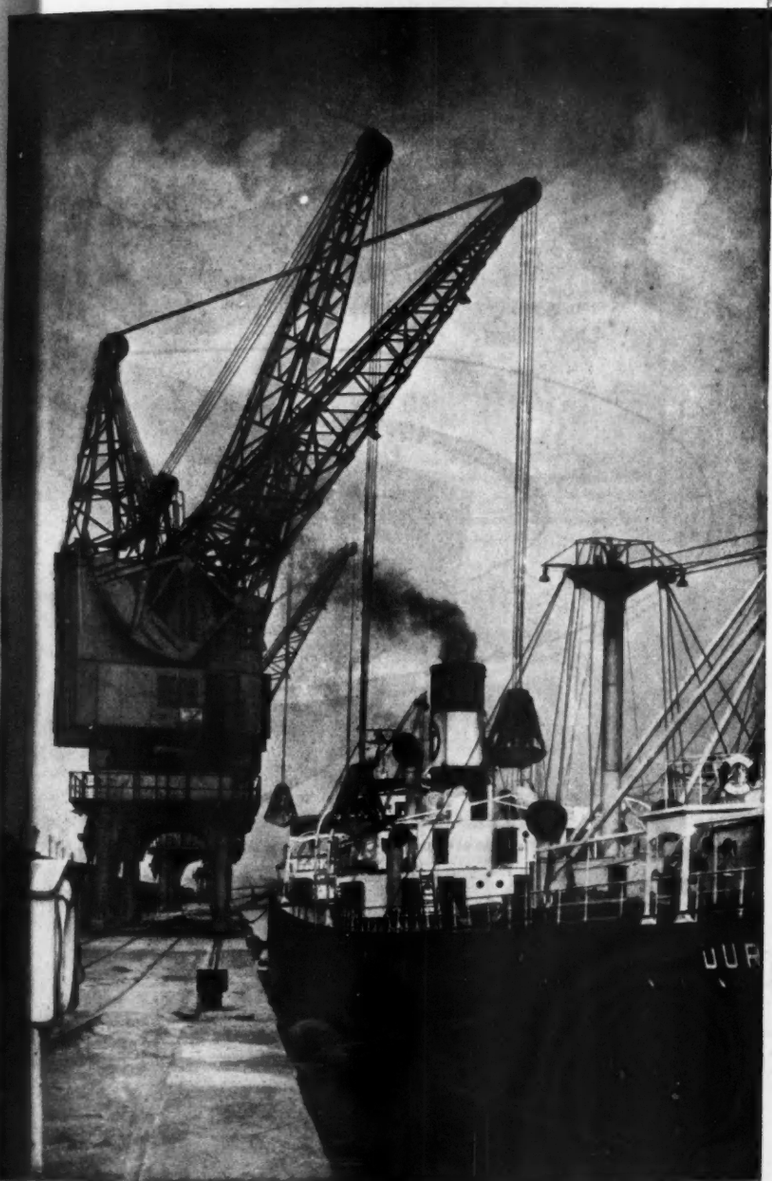

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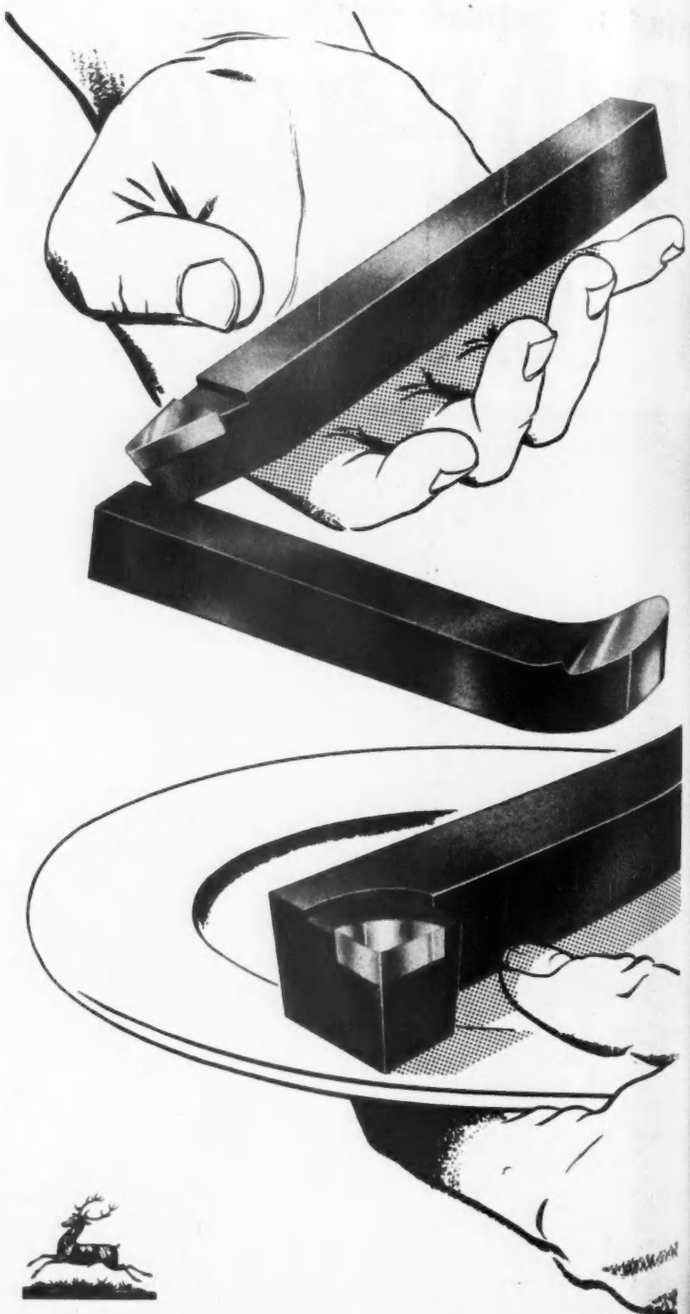

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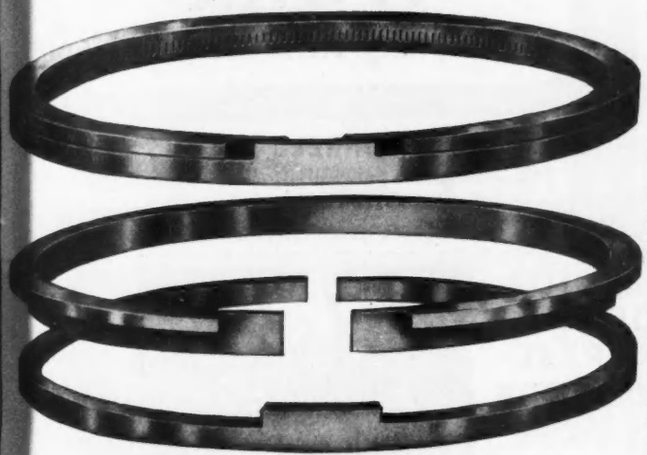

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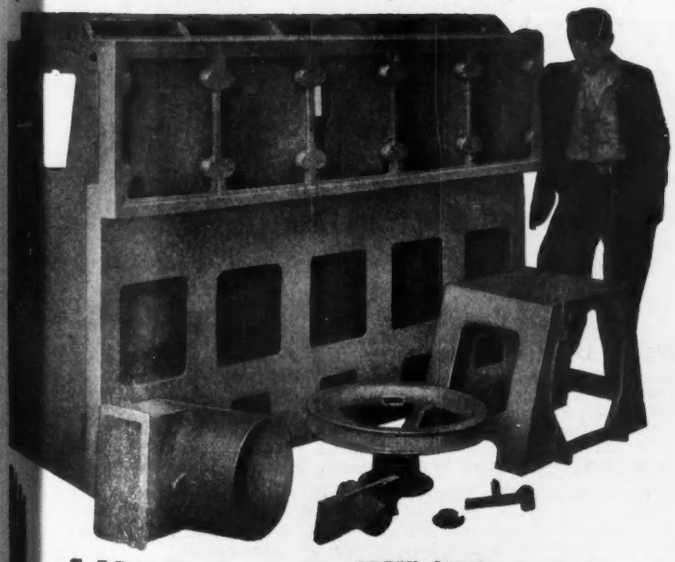

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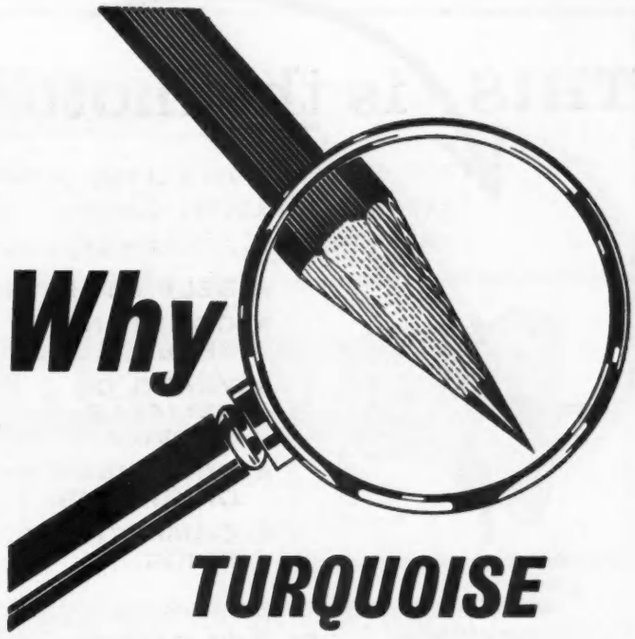

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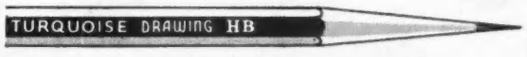

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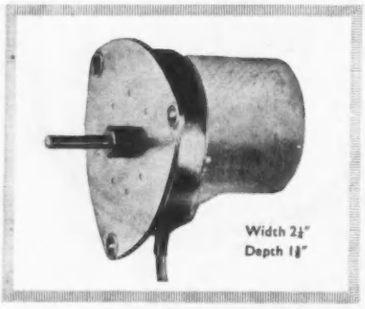

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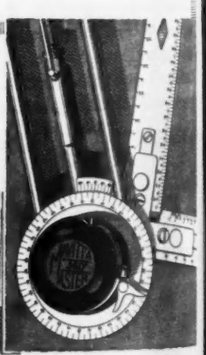

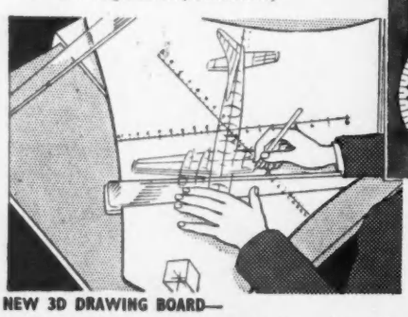

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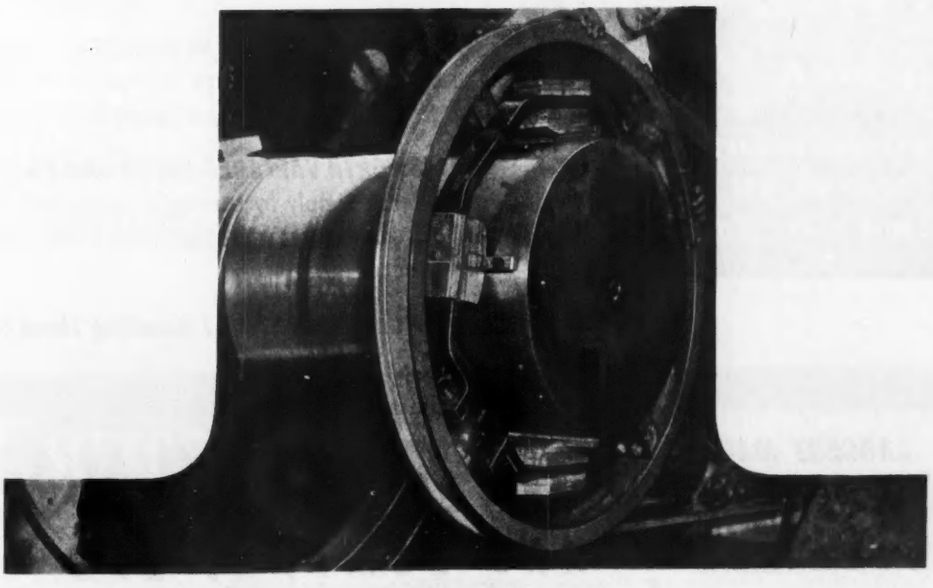

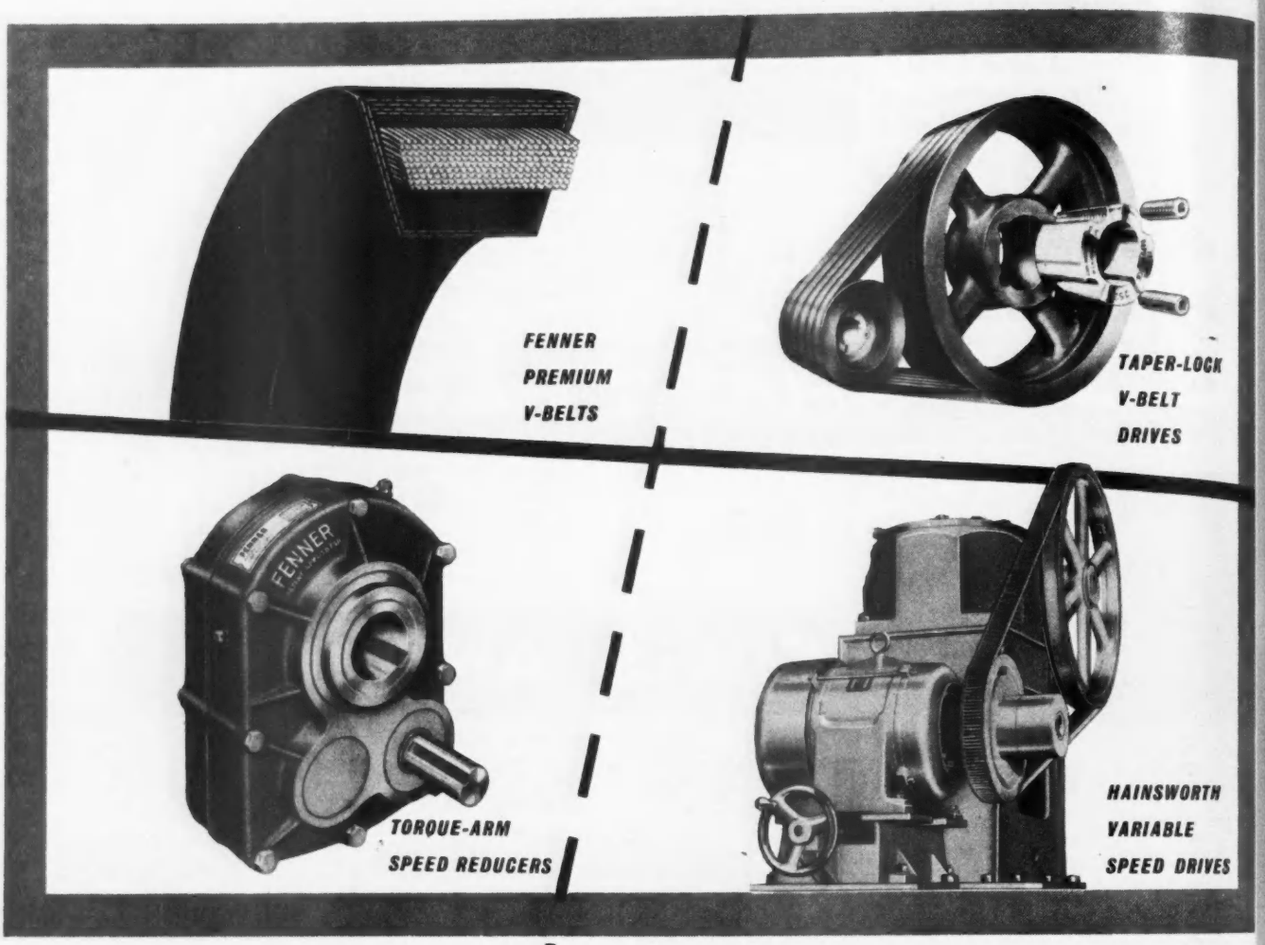

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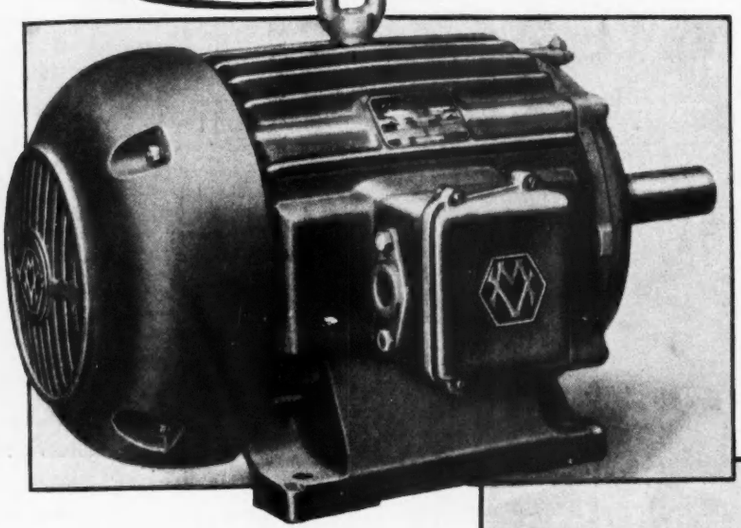

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TEFC ENCLOSURE
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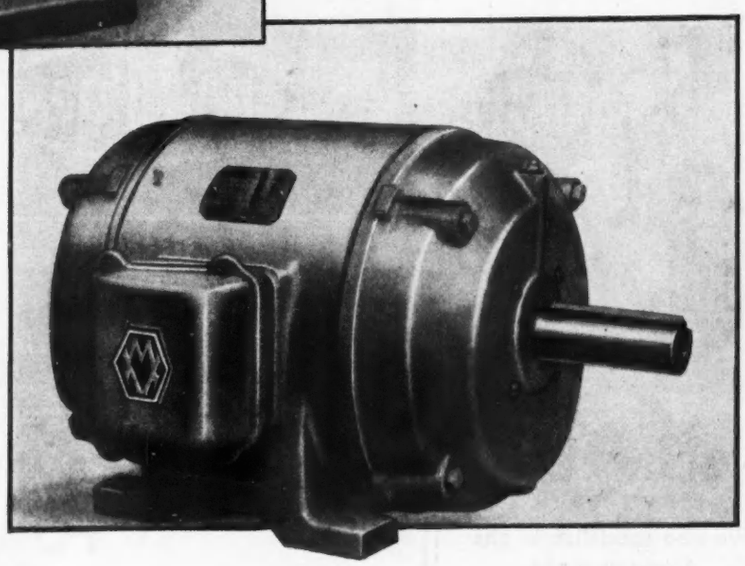

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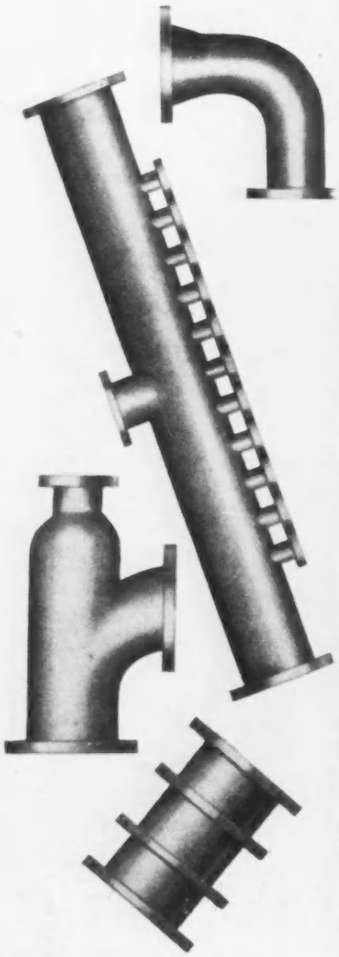

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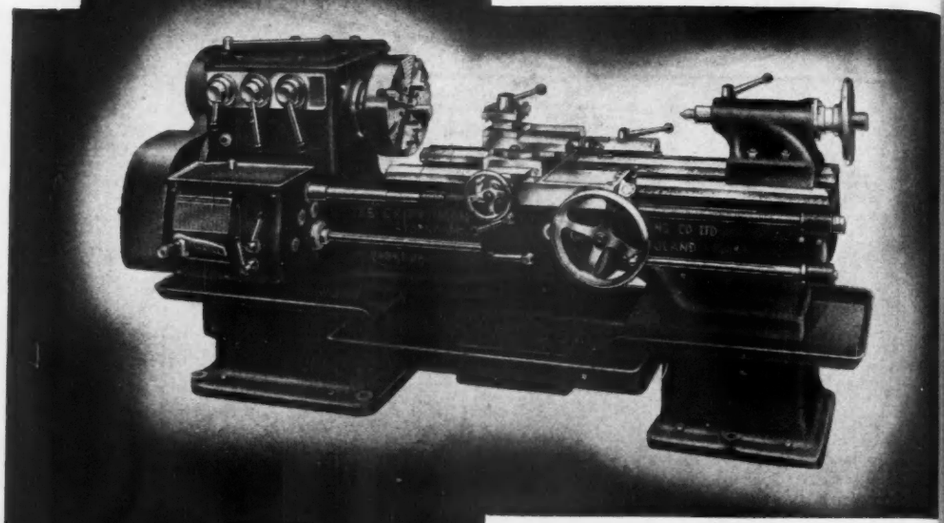

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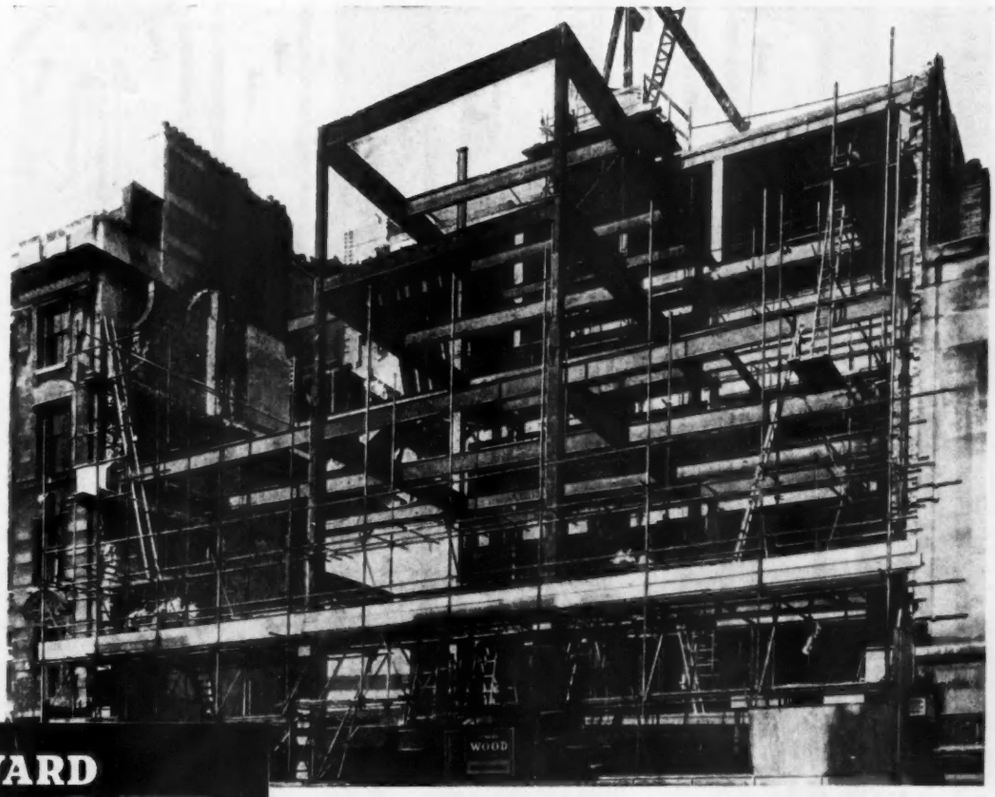

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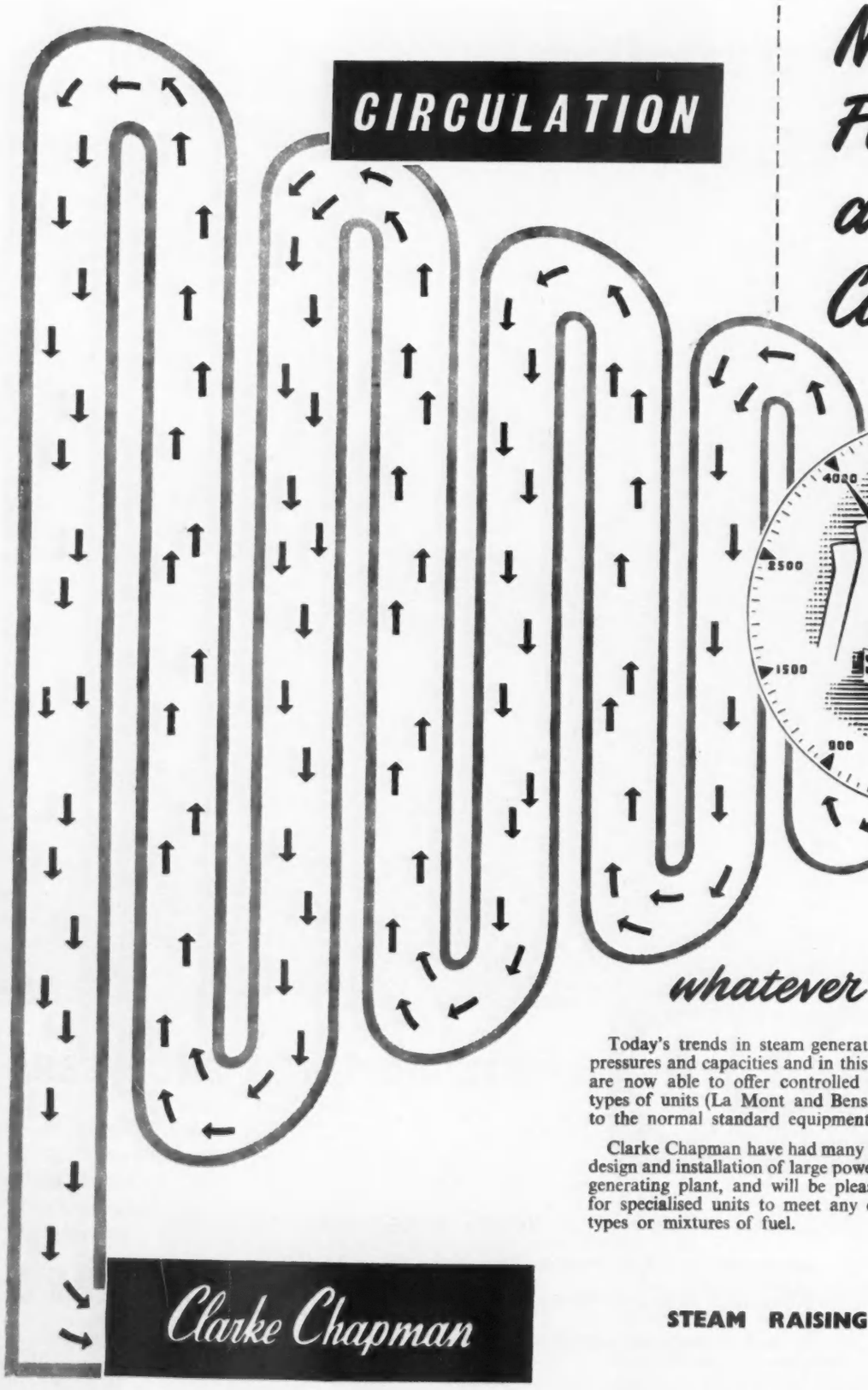

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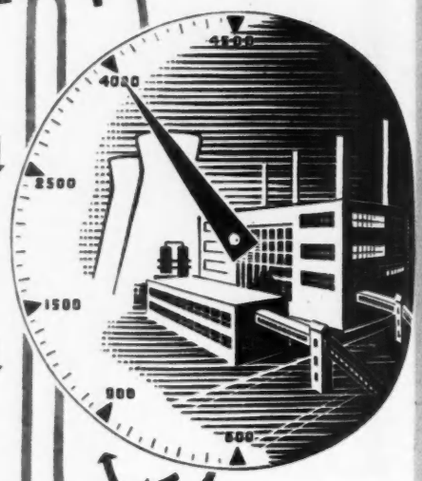

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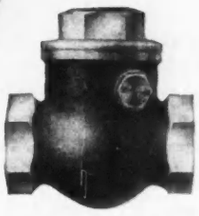

1060A HORIZONTAL or VERTICAL CHECK VALVE

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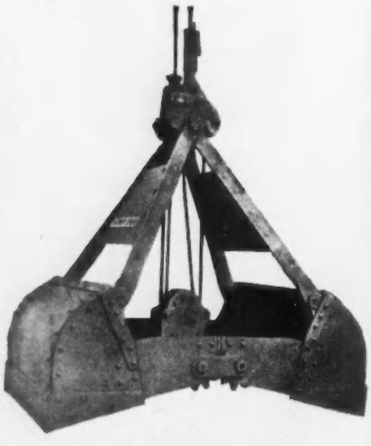

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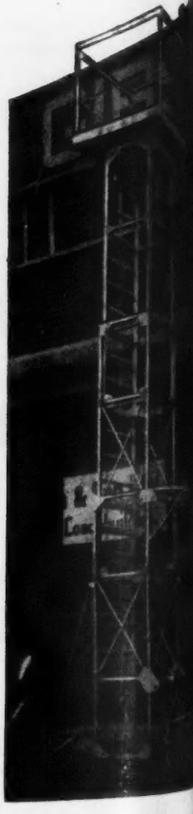

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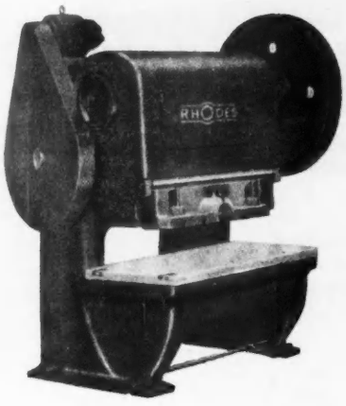

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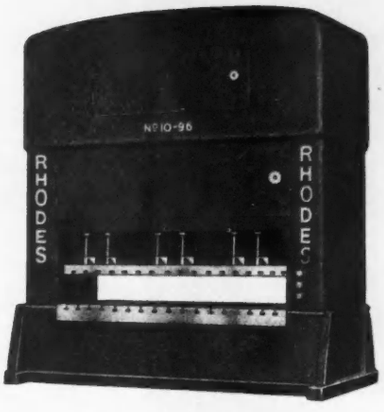

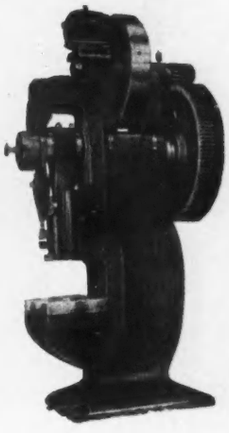

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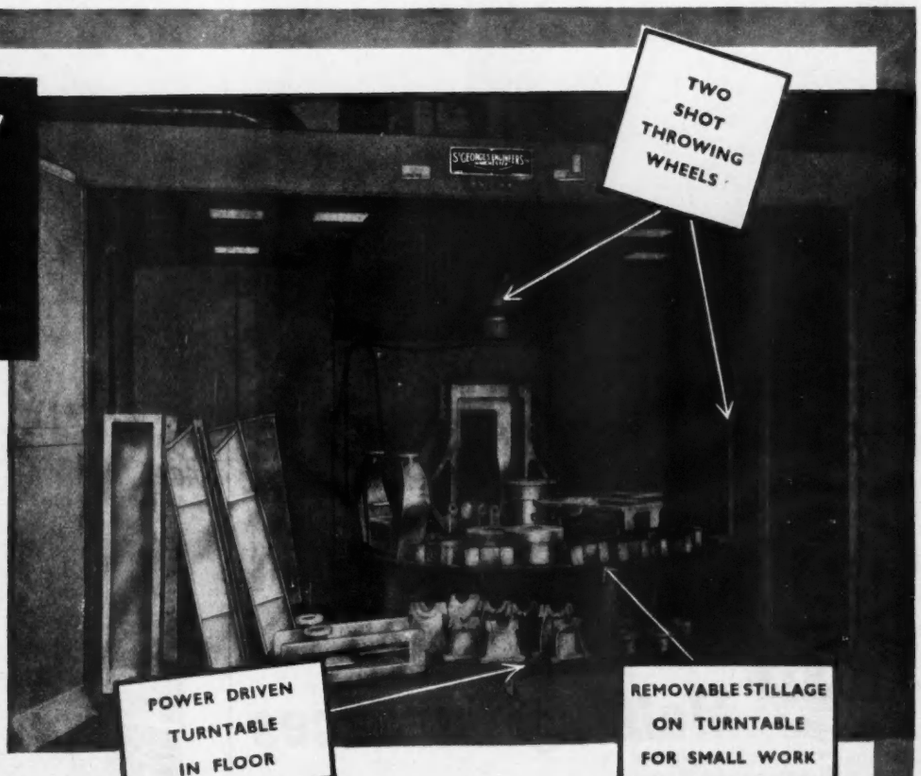

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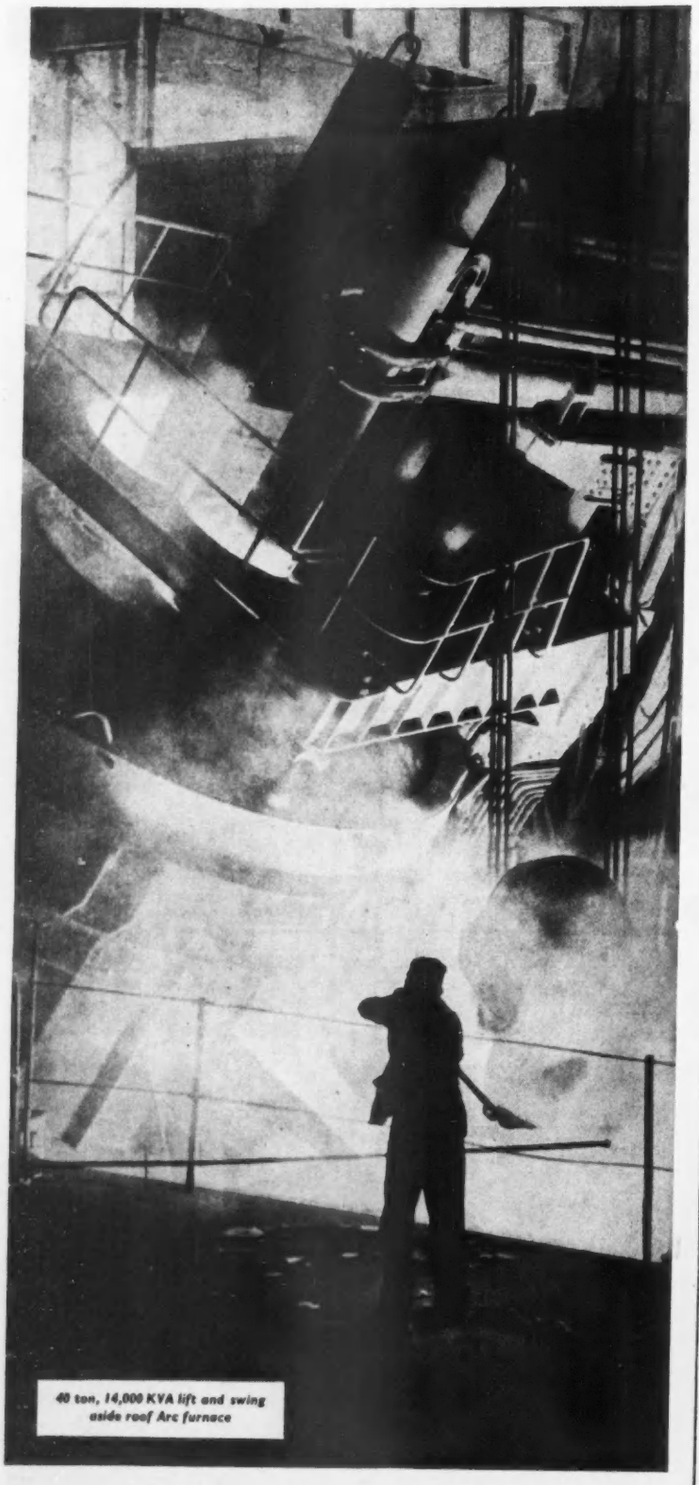

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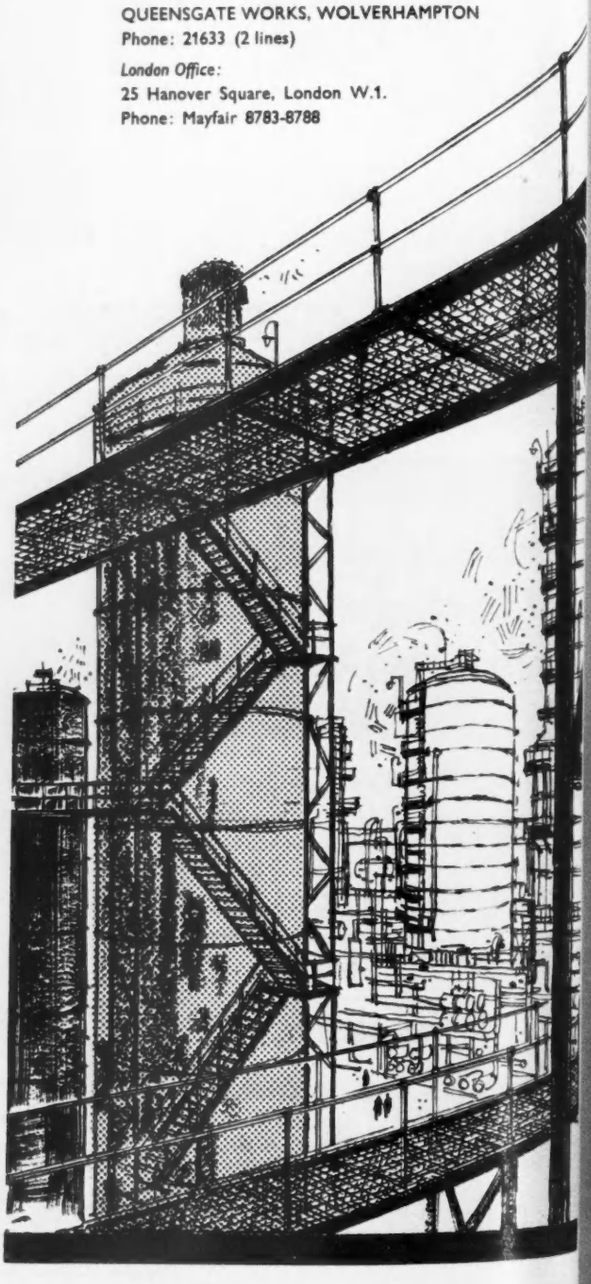

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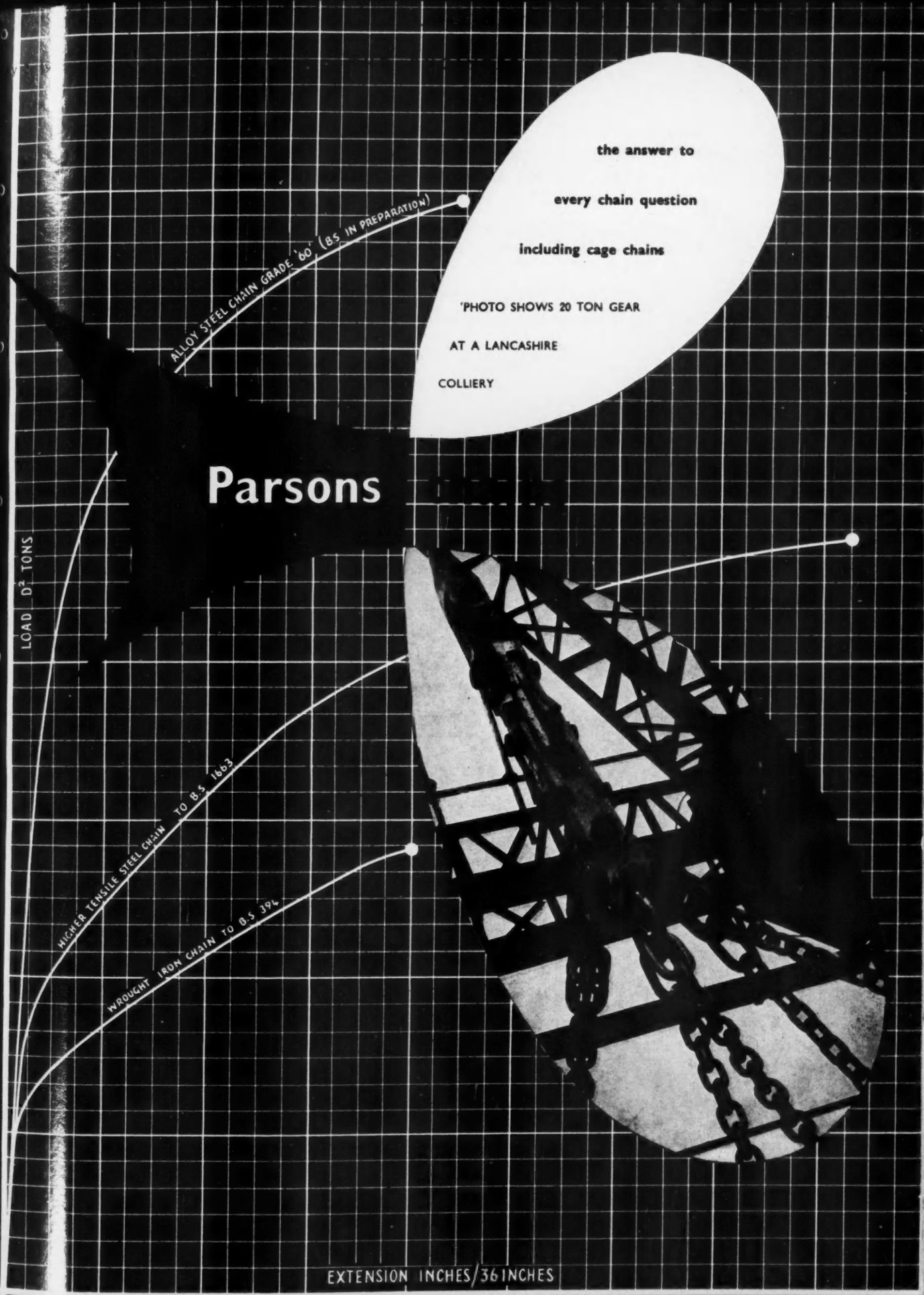

The world's largest turbo-generator for Britain

THE CENTRAL ELECTRICITY Generating Board have ordered a PARSONS 550,000 kW turbo-generator to be installed in the projected Thorpe Marsh Power Station, Yorkshire. This machine, the largest generating set in the world, will consist of two lines arranged in line ahead, each line comprising four cylinders driving a 275,000 kW three phase generator.

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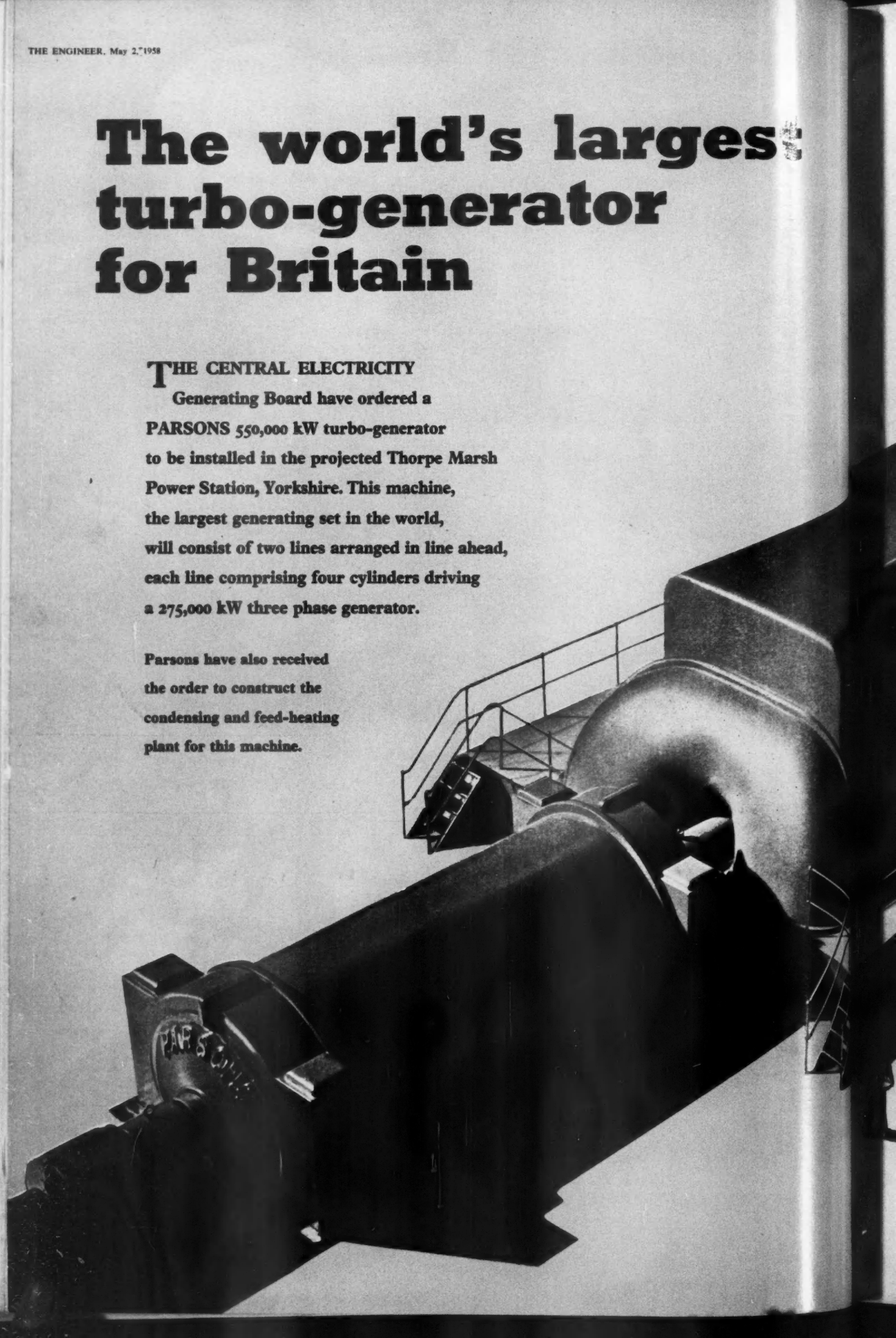

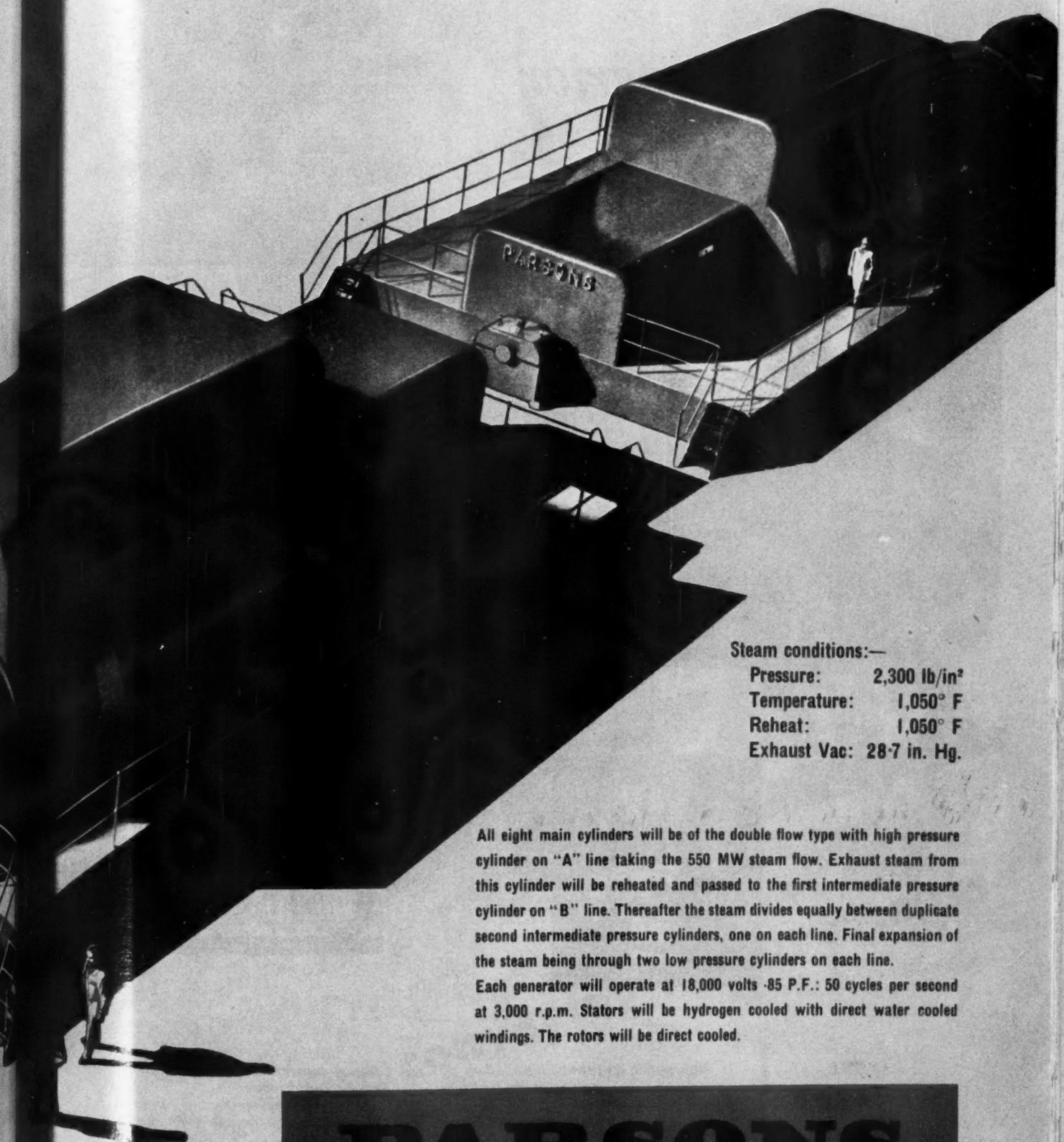

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Exhaust Vac:	28·7 in. Hg.

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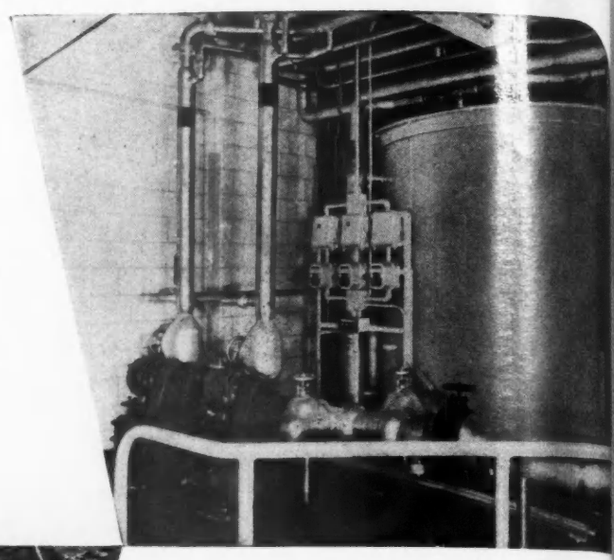

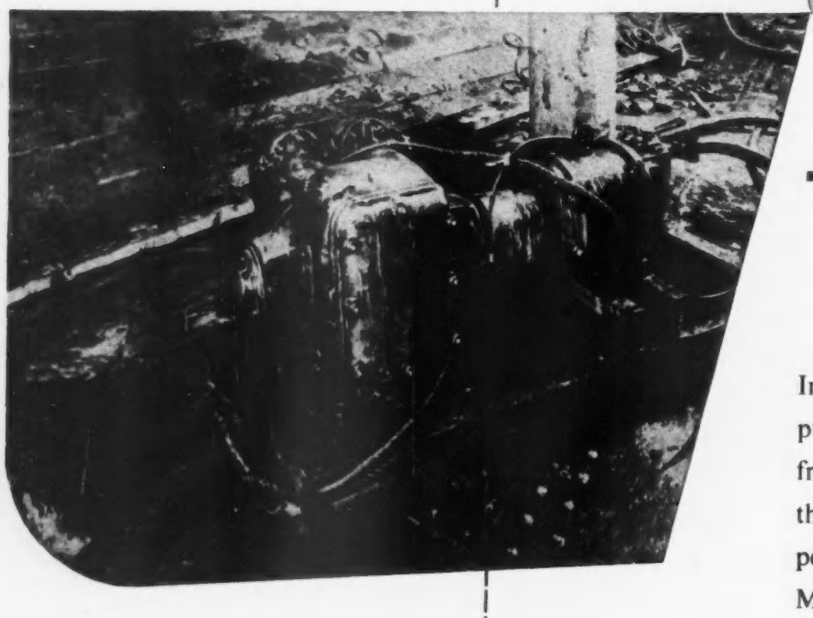

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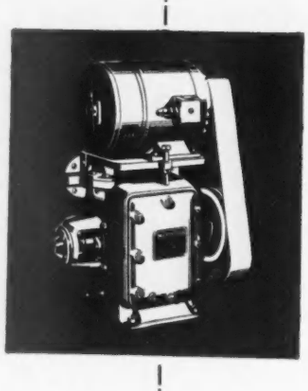

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SOME MEGATOR FACTS

***High suction lift** permits installation in convenient positions.*
***Self-priming** inherent without any added device.*
***"Snoring"** ability sucks out the lost drop.*

***Constant capacity** at varying pressures.*
***Sustained performance.** Self-compensating for wear.*
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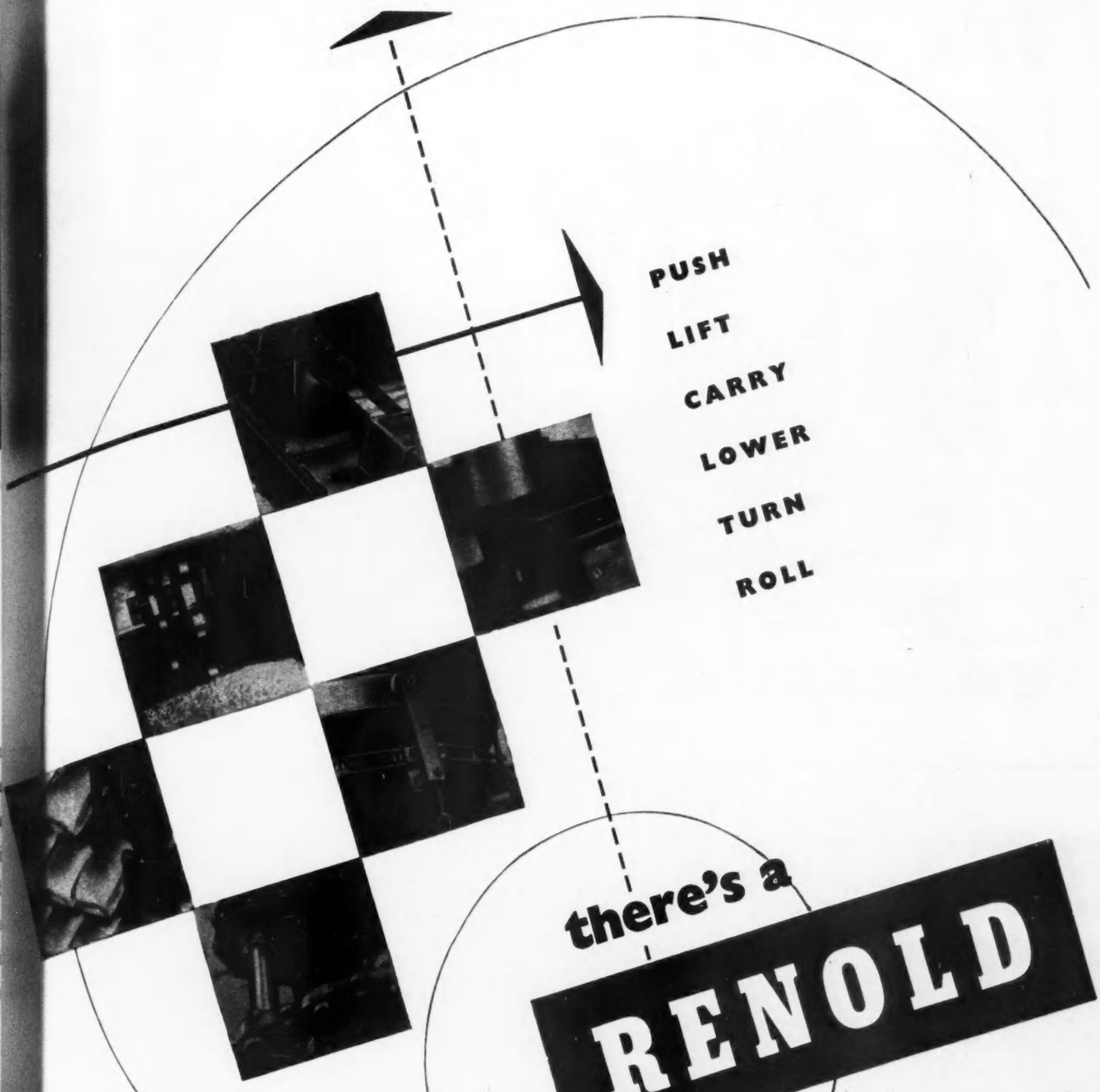

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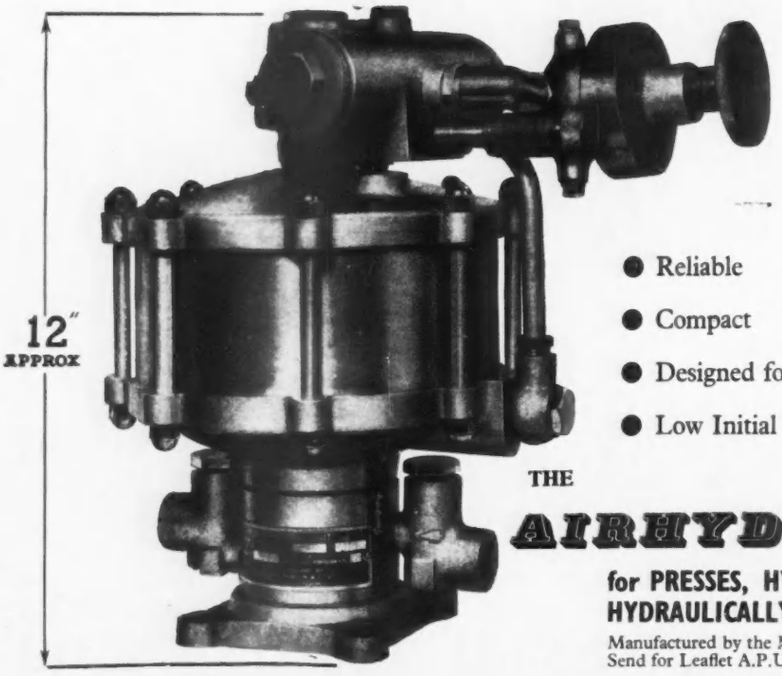

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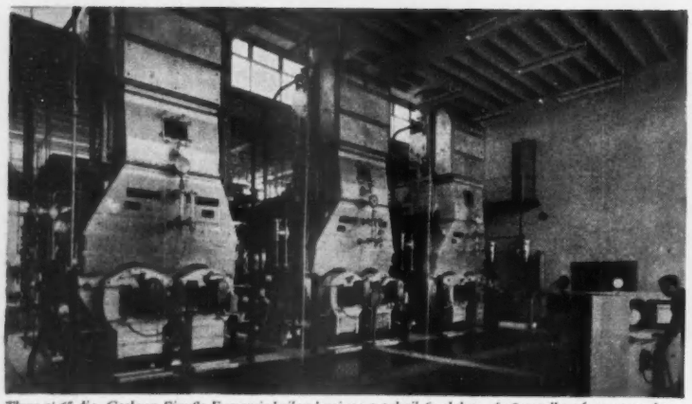
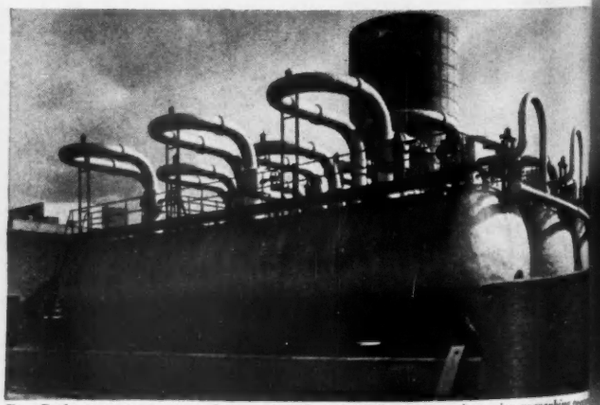


Three 9' 6" dia. Cochran Sinuflo Economic boilers having a total oil-fired duty of 38,000 lbs. of steam per hour at 250 p.s.i.



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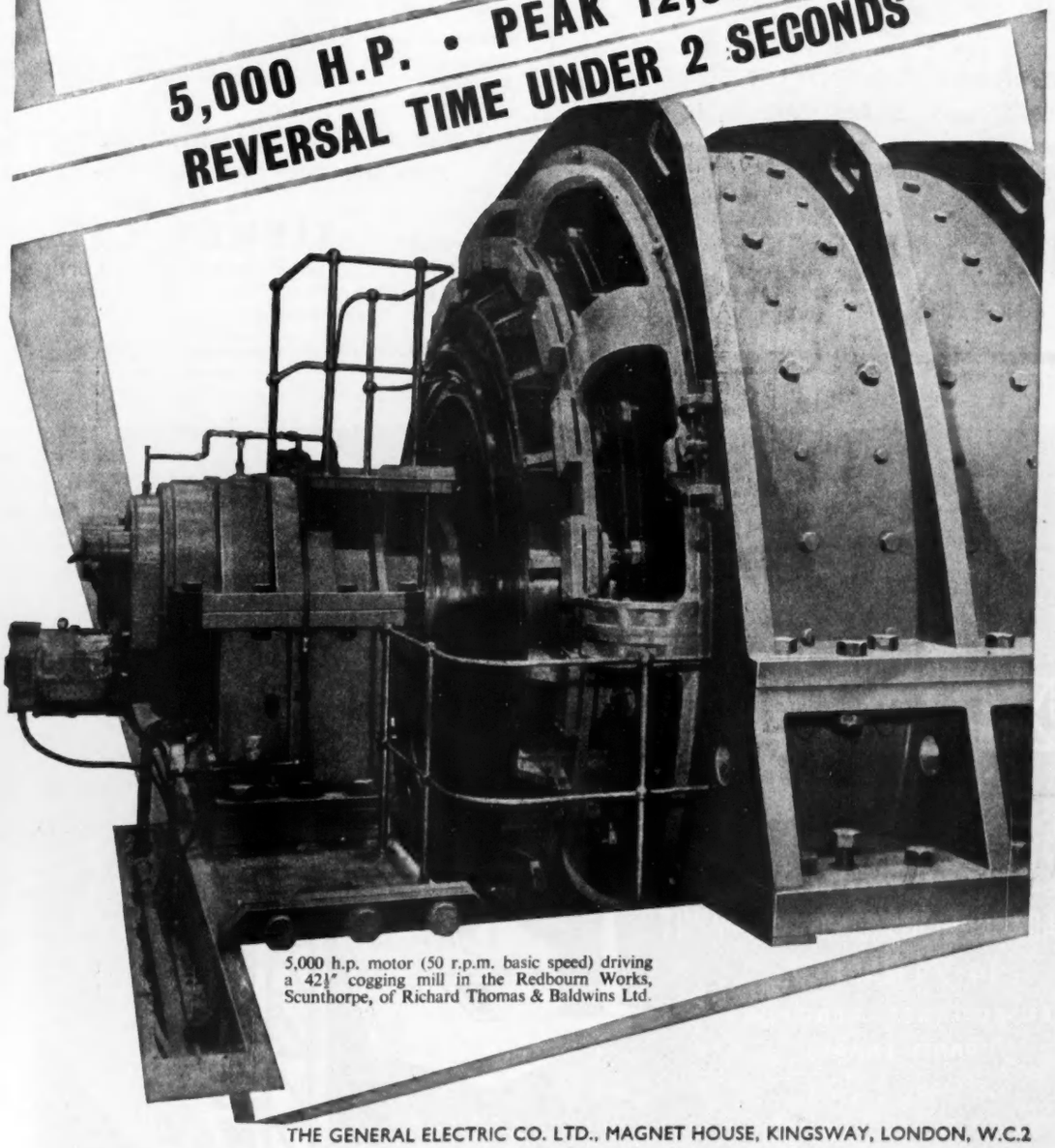

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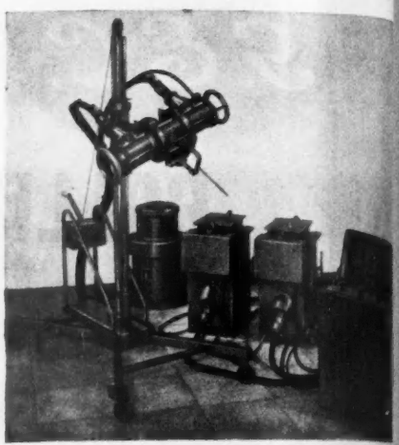

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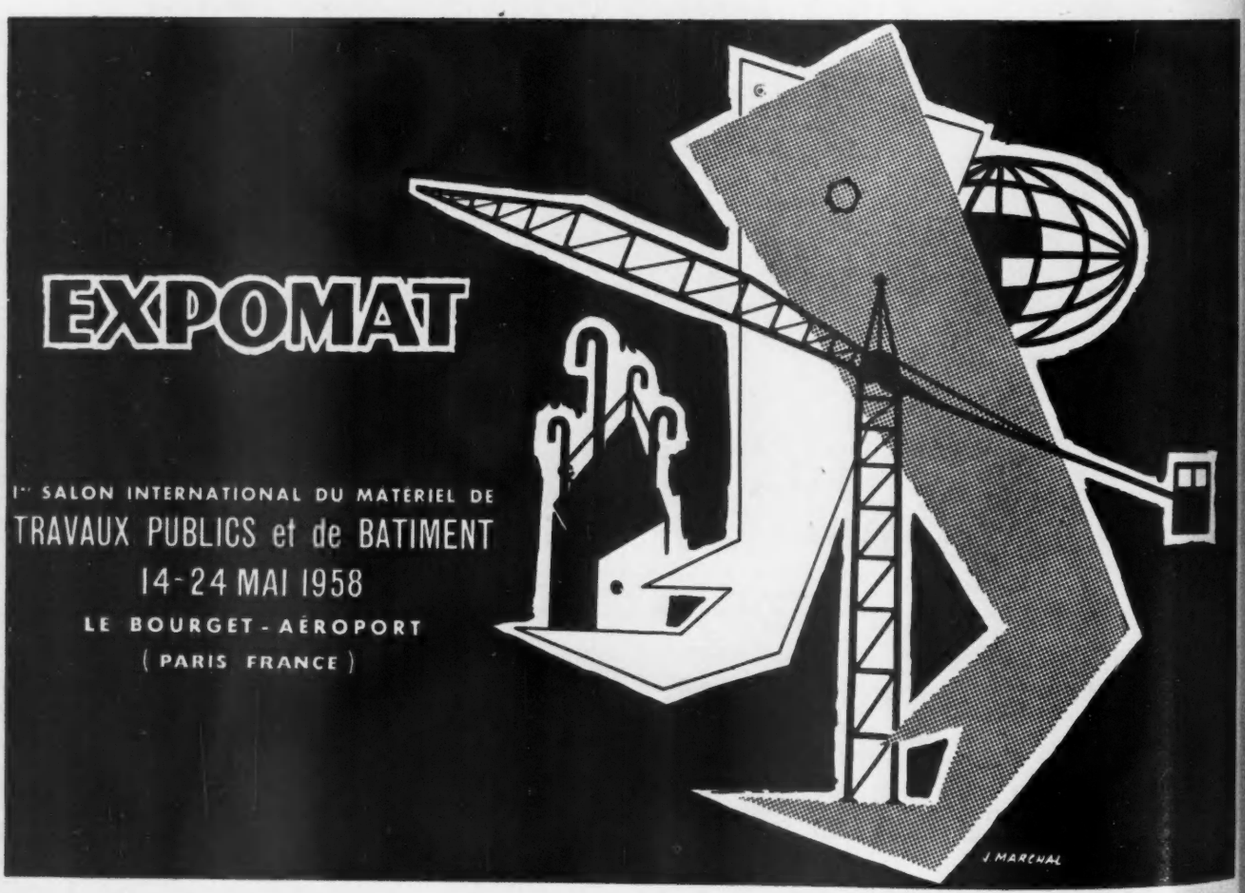

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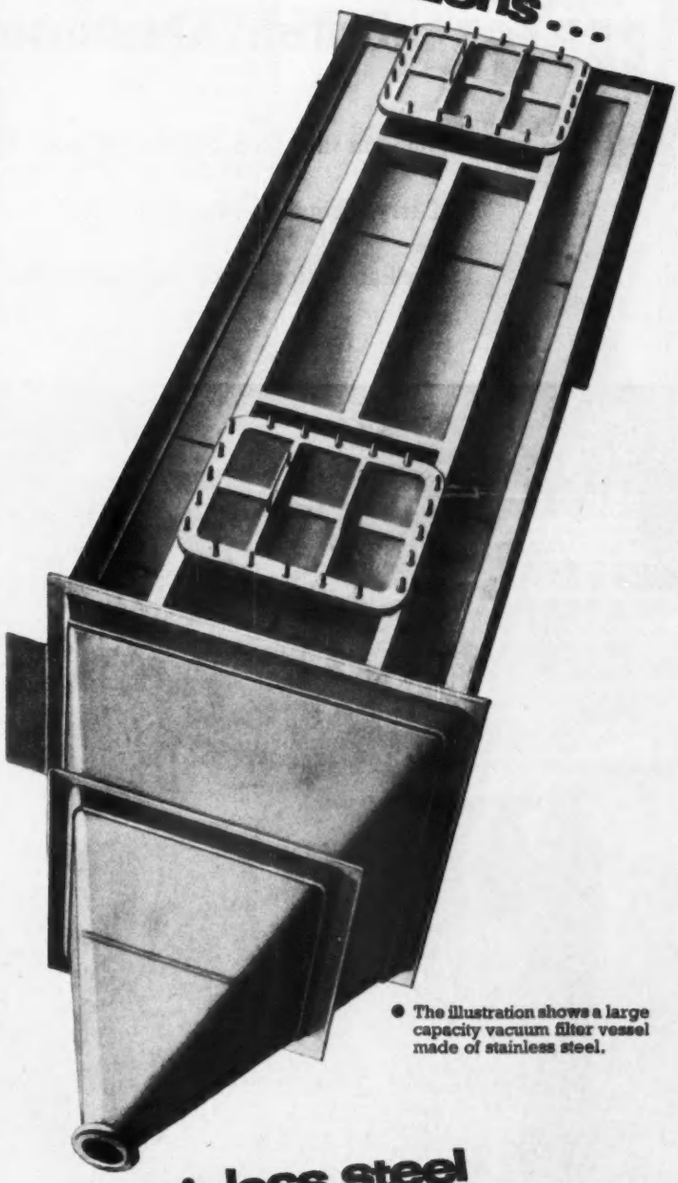

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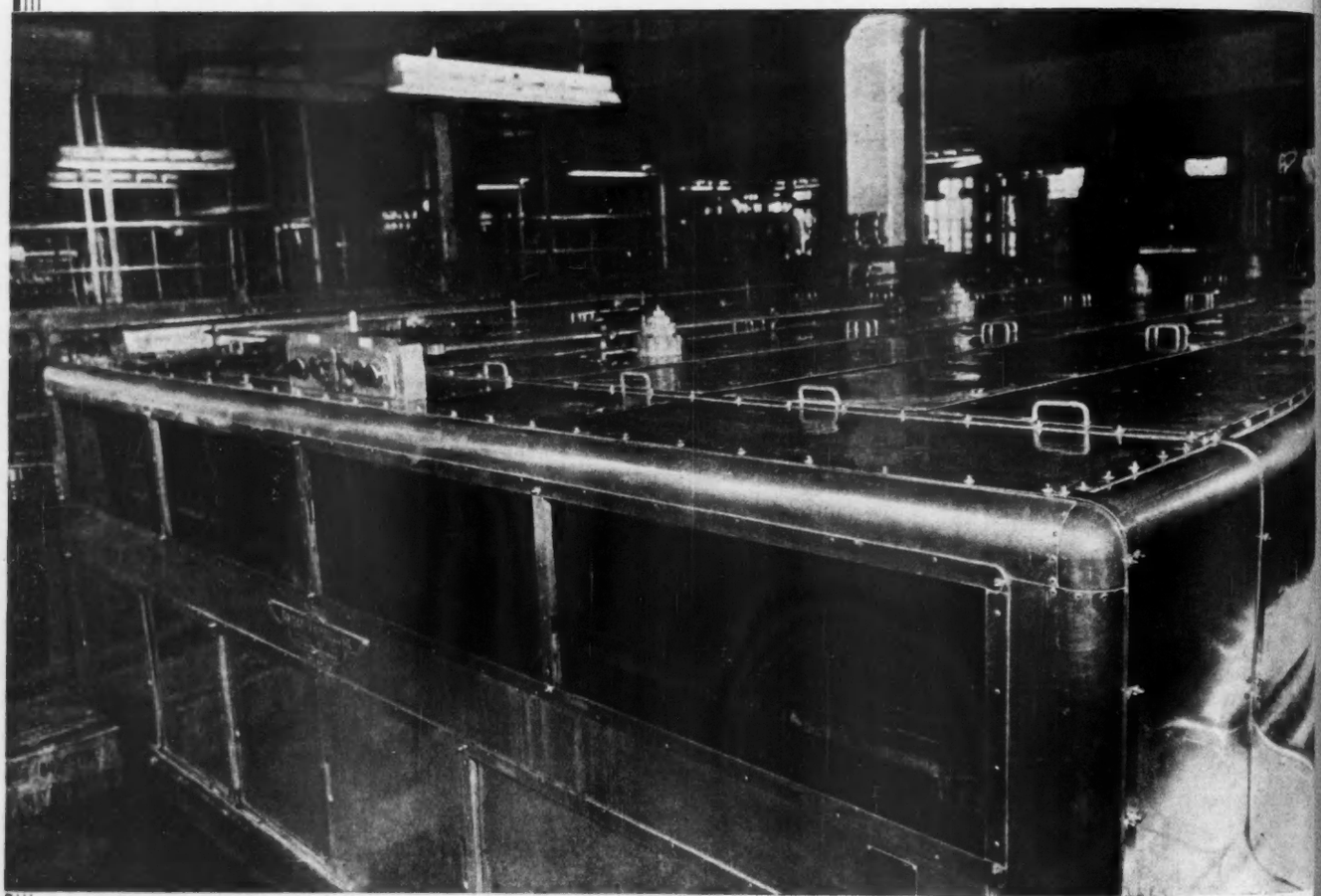

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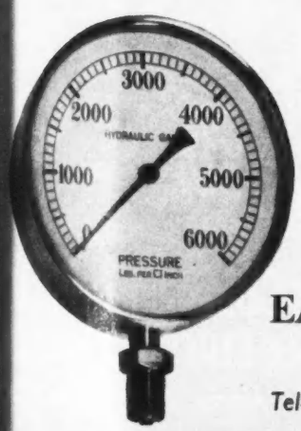

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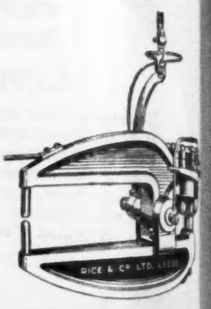

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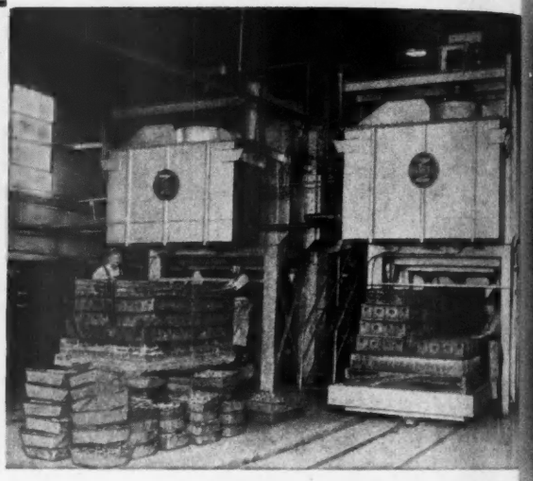

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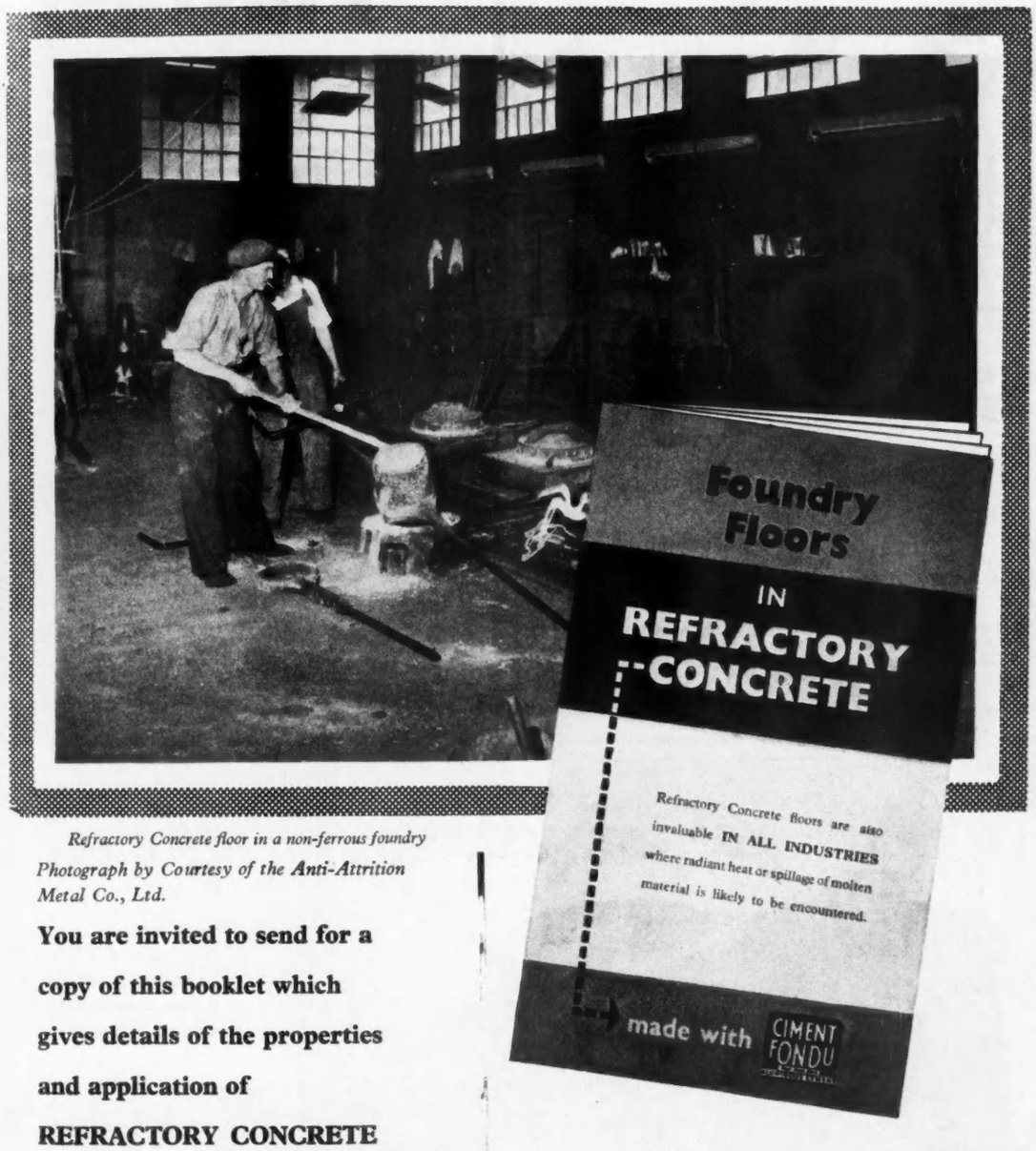
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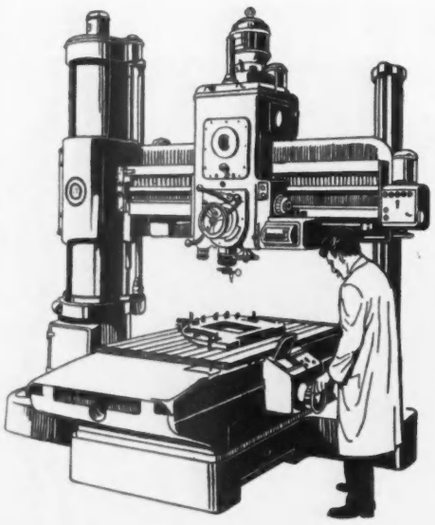

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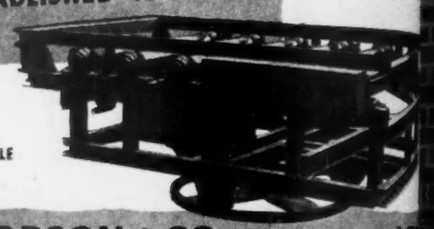

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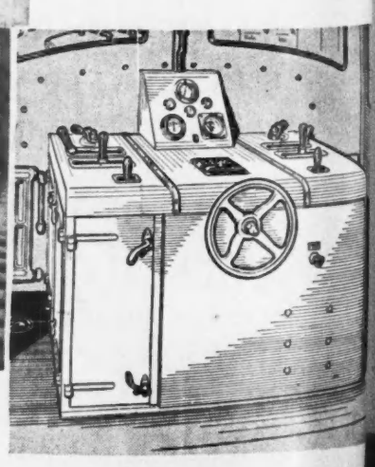

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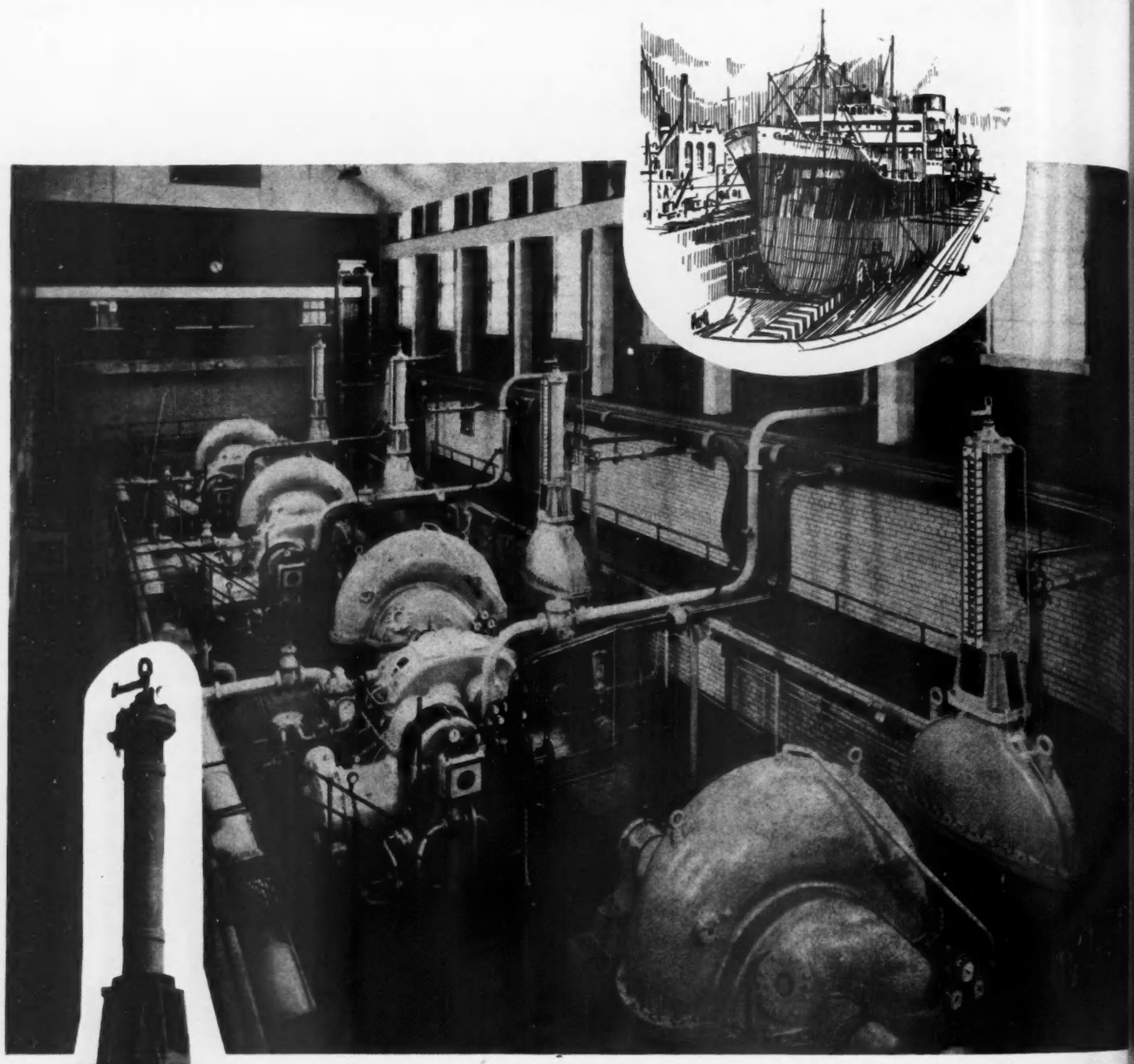

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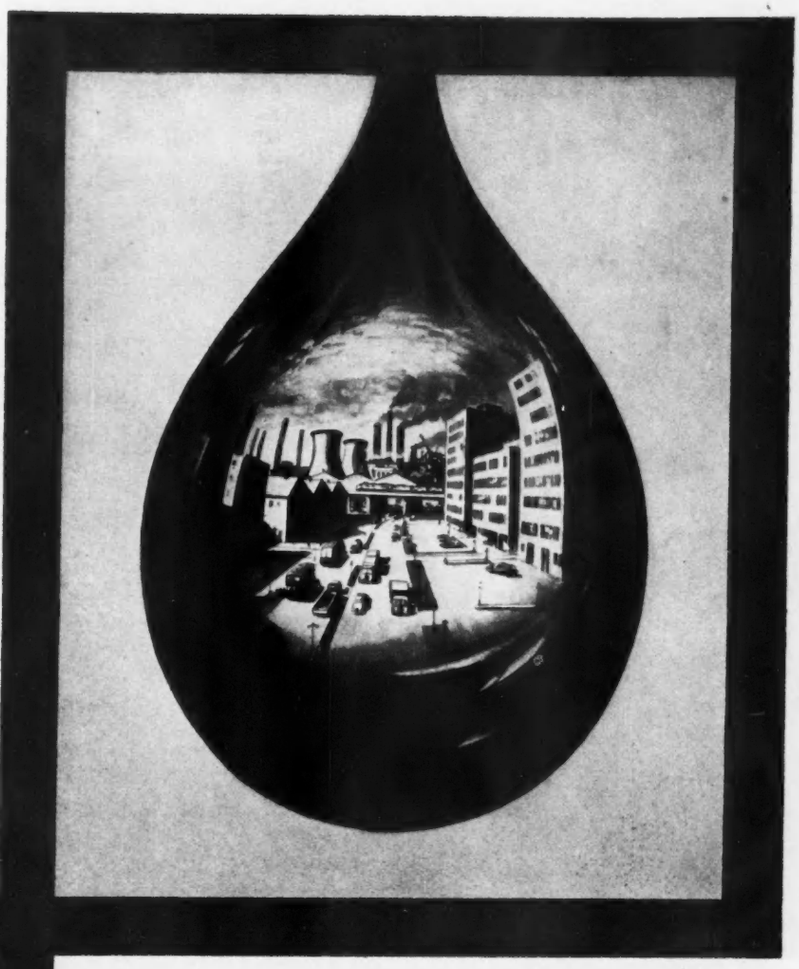

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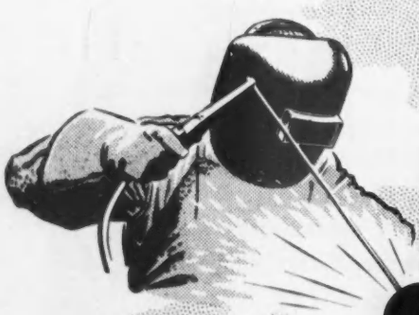

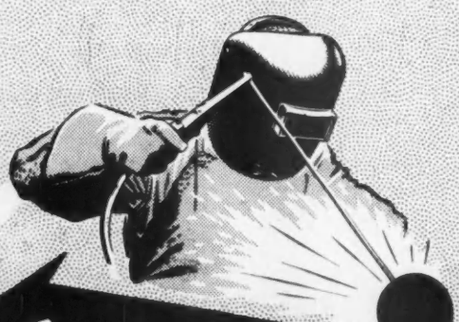

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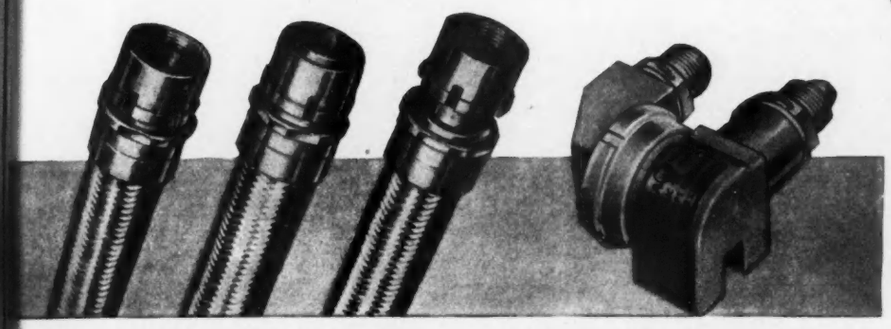

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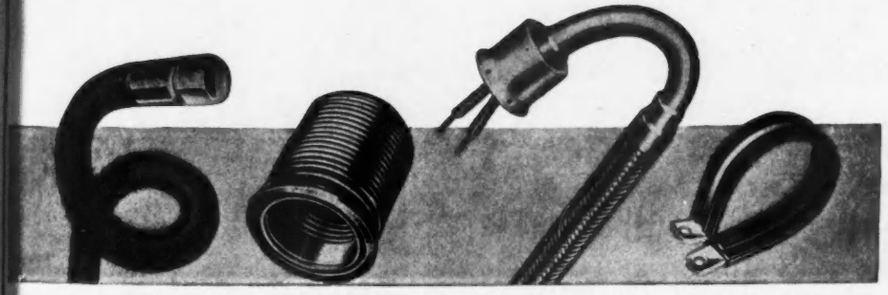

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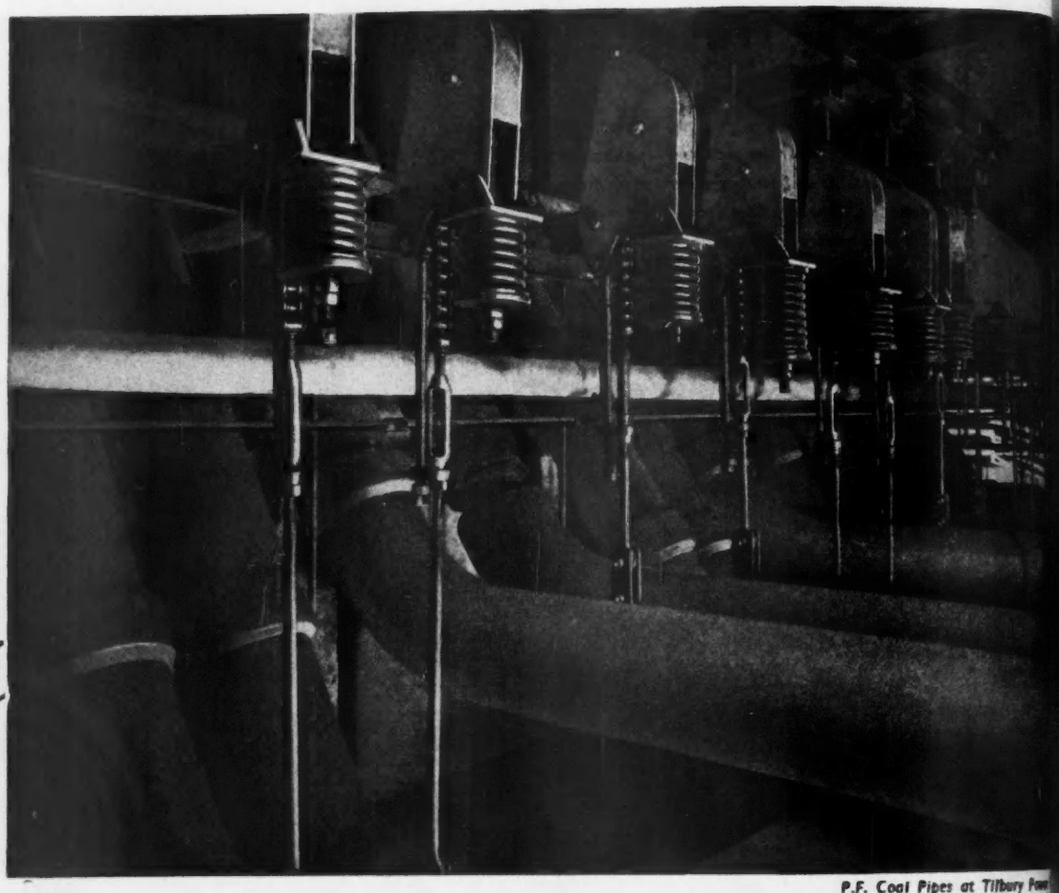

P.F. Coal Pipes at Tilbury Pow
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High-pressure steam piping is subject to wide variations in temperature, which produce considerable expansion and contraction. Unless the pipe supports can absorb and compensate for this movement, severe stresses are set up which may result in fracture. The "Con-Ten" Pipe Support is designed to cradle any type of piping with constant tension under all conditions, throughout the range of movement. "Con-Ten" is installed, with eminently satisfactory results, in power stations, oil refineries, chemical and industrial plants throughout the world.

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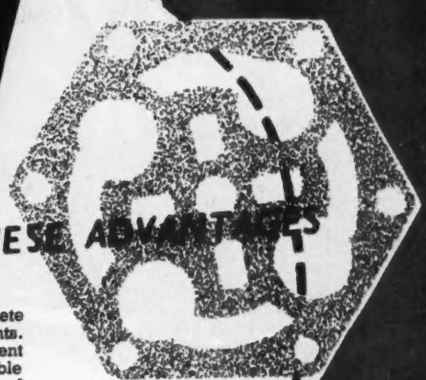

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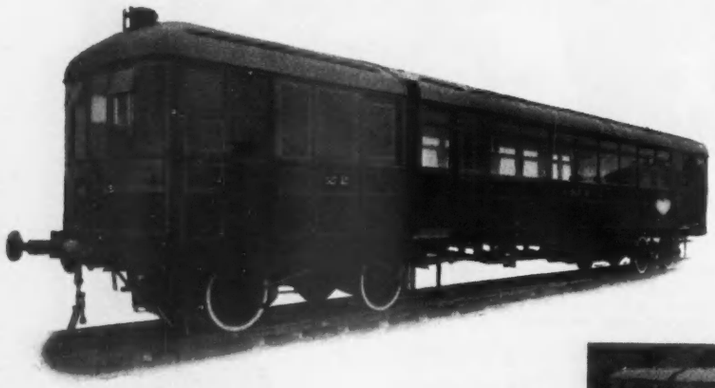

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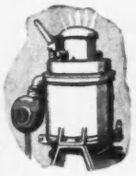

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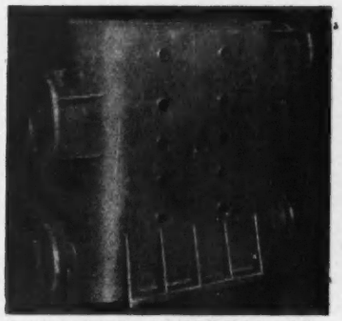

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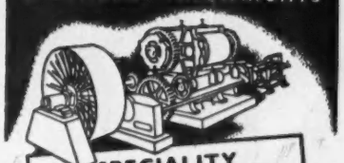

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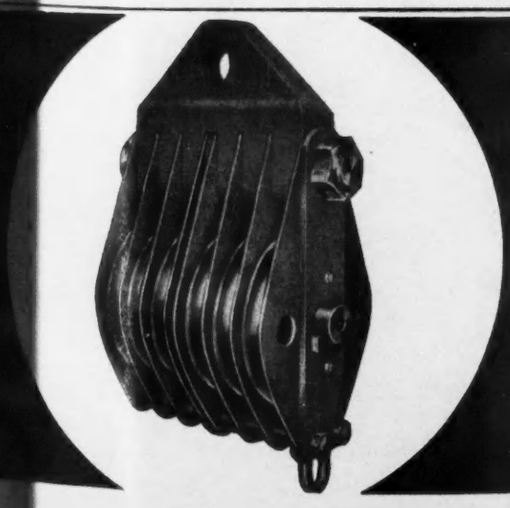

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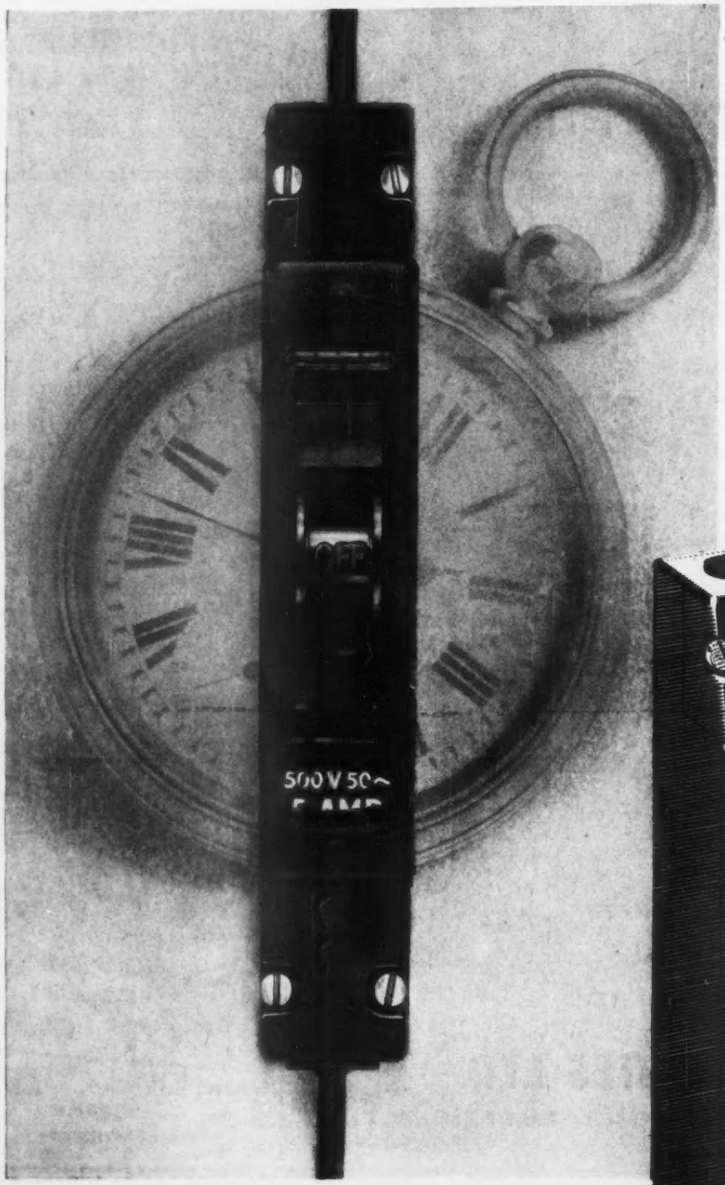
CRABTREE MINIATURE CIRCUIT BREAKERS



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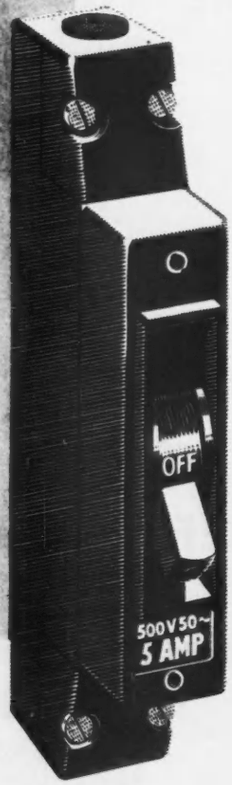

WHY THE USER PREFERS CIRCUIT BREAKER PROTECTION

"I can myself identify the faulty circuit and restore the supply without further help"

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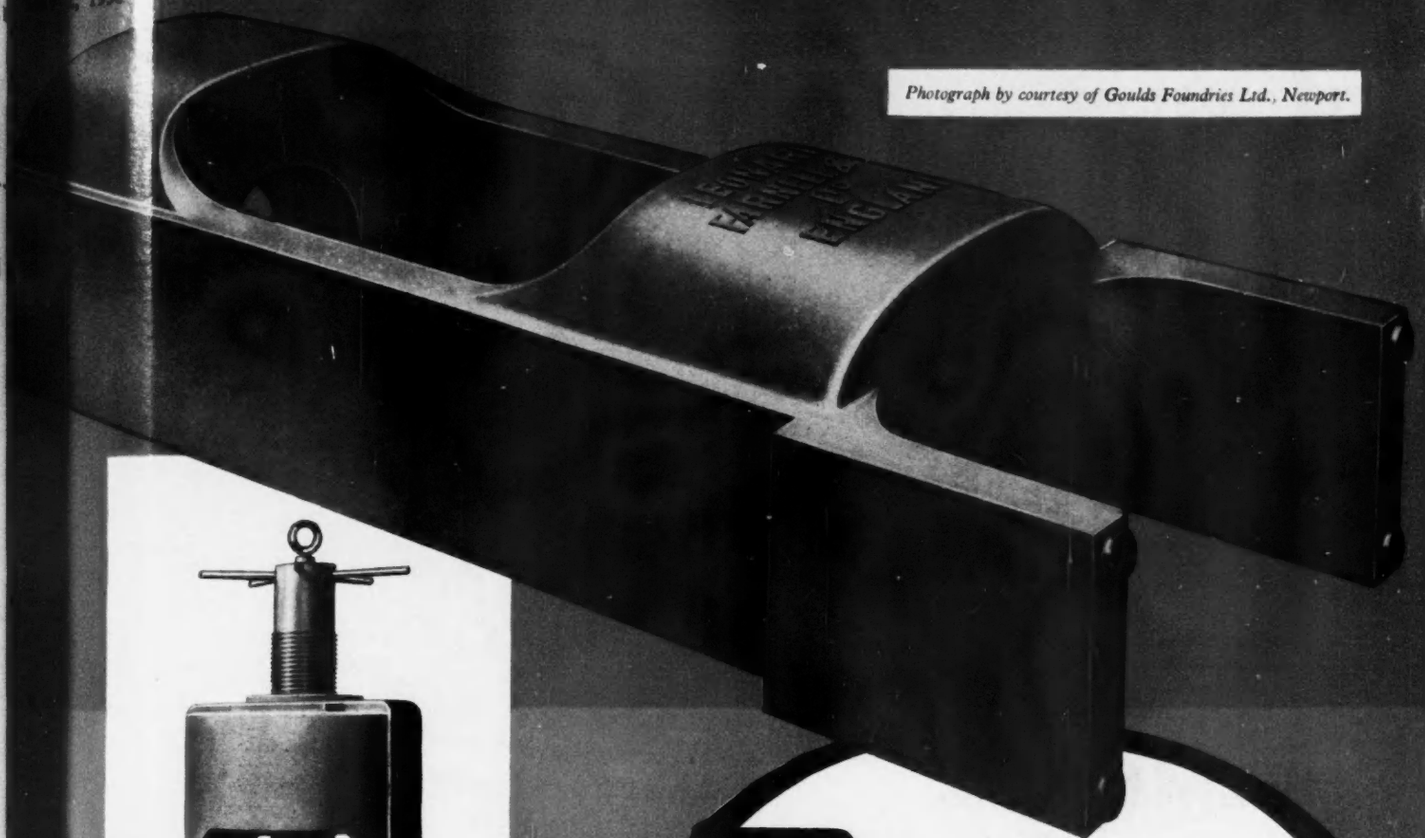
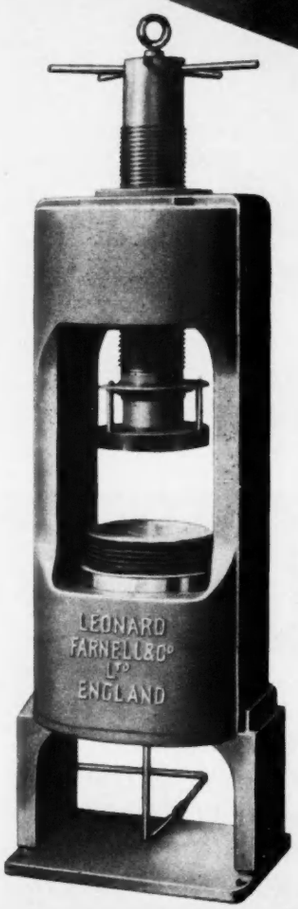


Photograph by courtesy of Goulds Foundries Ltd., Newport.



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One of the tests for concrete involves the application of a compressive load to a cube specimen until failure occurs. This load may exceed 10,000 lbs/sq. in.

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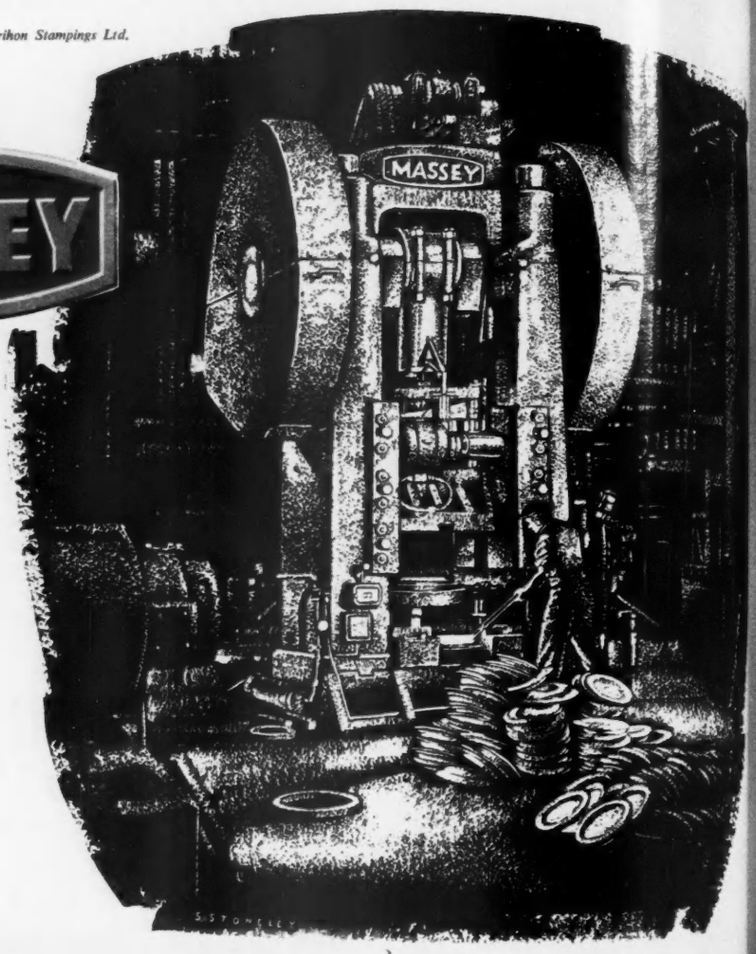

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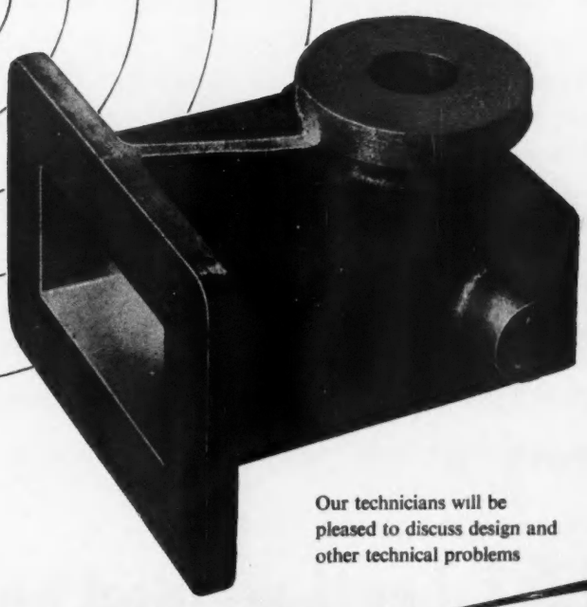

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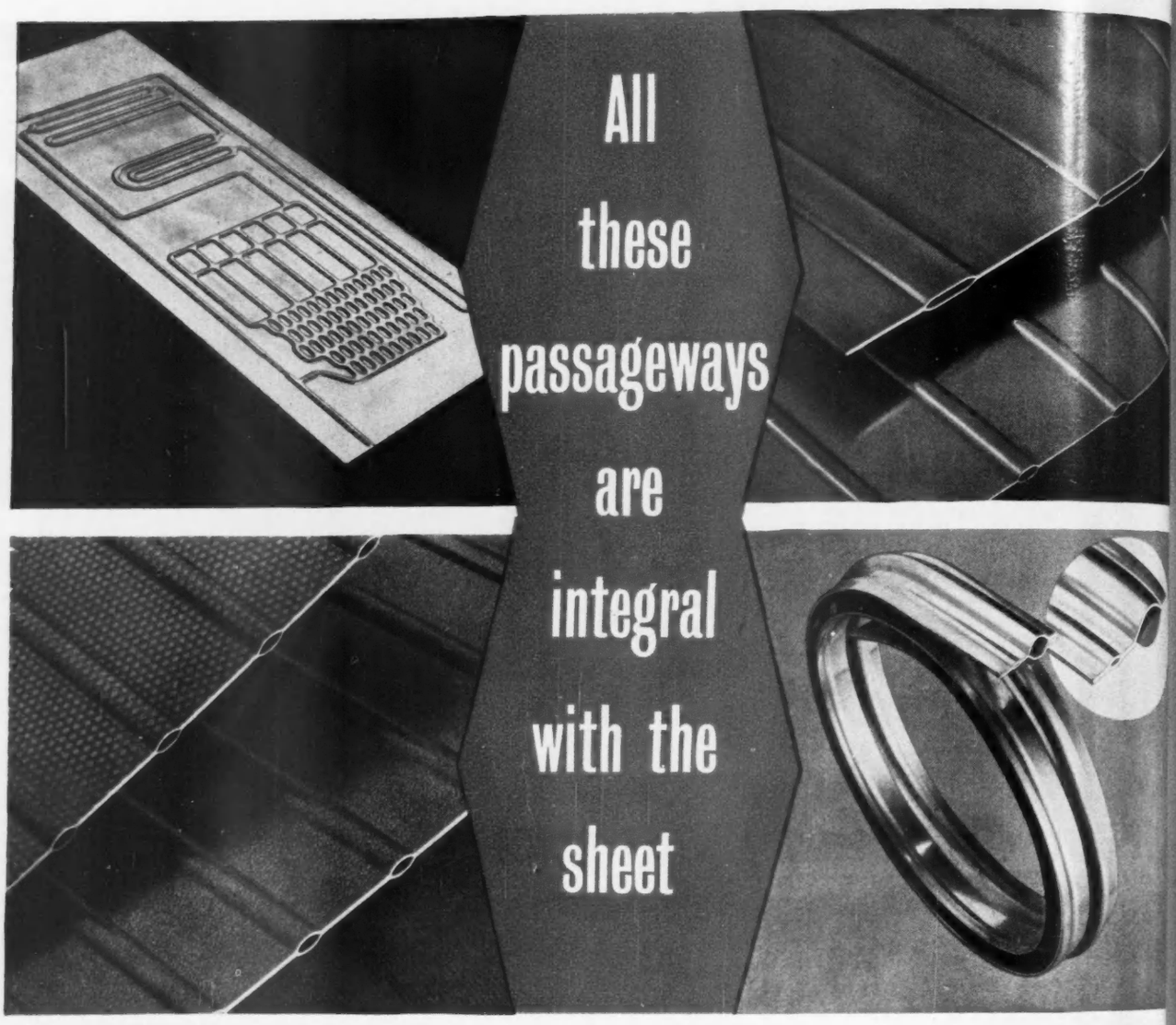

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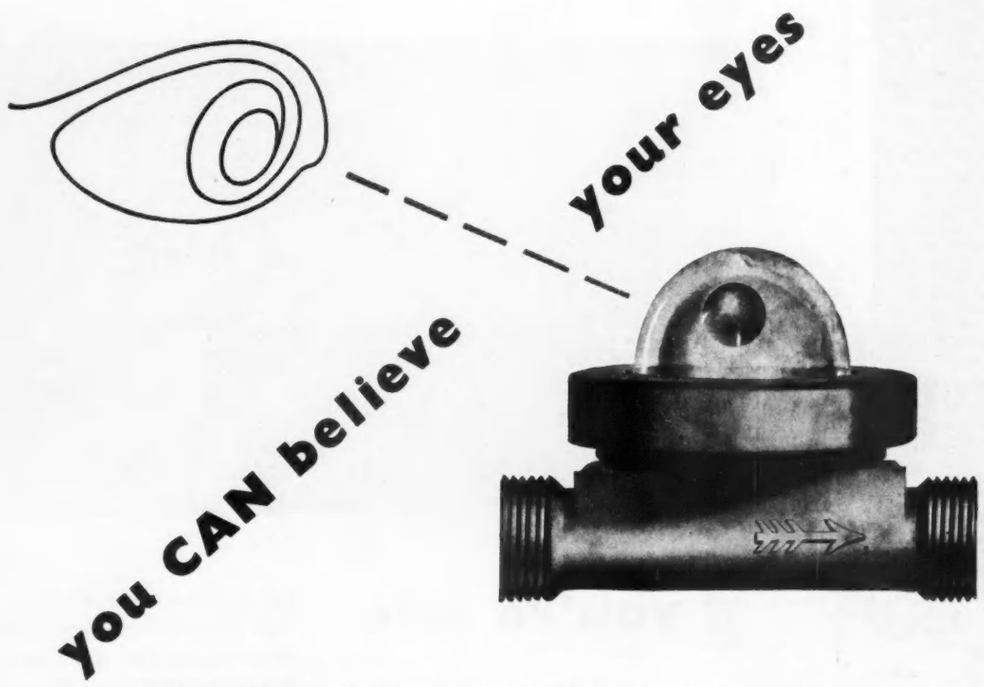

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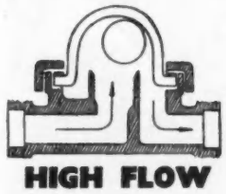

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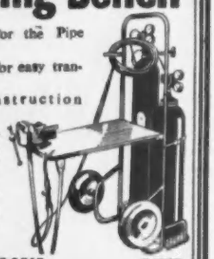

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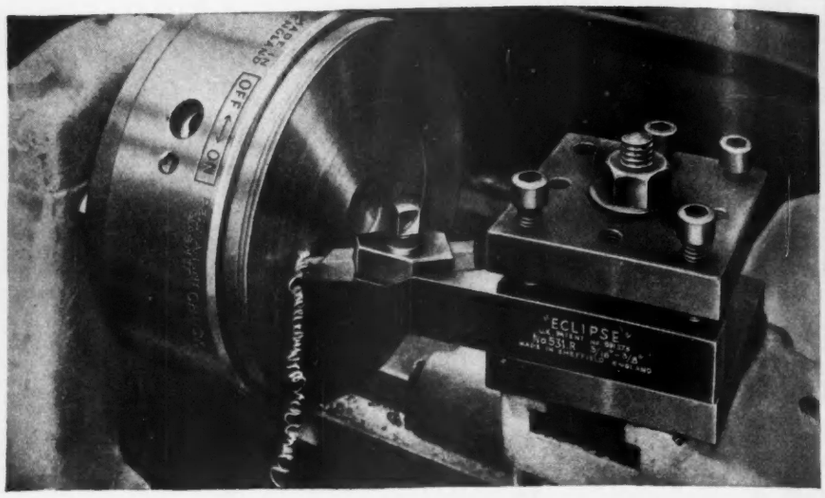

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ECLIPSE tool bits are made from H3 Cobalt High Speed Steel in squares and rounds and as cutting off tools and boring bars. The ECLIPSE tool holder really makes sure that the tool is rigidly held. Ask your tool dealer for details of sizes and patterns.

Eclipse tool bits and tool holders

'Eclipse' tool bits, tool holders and other tools are made by James Neill & Co (Sheffield) Ltd. and are obtainable from all tool distributors

SLUDGE Disposal

Residue sludge or slurry often creates a major problem of disposal. It may be viscous or carry solids in suspension and it is frequently corrosive or abrasive. The Mono Pump has shown a great ability at handling such mixtures and has saved considerable manpower, time and money by pumping sludge effluent direct from pits and settling tanks to transportation for disposal or to plants for by-product recovery. The Mono Pump is self-priming, positive in action and has a high suction power. It is simple and needs the minimum attention.

The MONO pump

MONO PUMPS LIMITED
MONO HOUSE · SEKFORDE STREET · LONDON, E.
Telephone: CLErkenwell 8911
Telegrams: Monopumps 'Phone London

and at Belfast, Birmingham, Capetown, Dublin, Durban, Glasgow, Johannesburg, Manchester, Melbourne, Newcastle, Wake

INDUSTRIAL & TRACTION GEARS

EPICYCLIC TYPE REDUCTION GEARS

Ratios 3: 1, to 1200: 1, Maximum Efficiency—minimum space: Horizontal or Vertical Mounting.
The most efficient method of obtaining a low speed drive, using a high speed motor, utilizing a minimum of space. We can offer single or multiple stage reductions from 3 to 1, up to 1200 to 1, for horizontal or vertical mounting.

Illustrated—MOTORIZED MULTIPLE STAGE UNIT—
Ratio 1100/1, 60,000 ins. lbs. torque output.

BOSTOCK & BRAMLEY LTD.

SPECIALISTS IN POWER TRANSMISSION
ODONTIC WORKS PHONE: STALYBRIDGE 3232-3 STALYBRIDGE A/21/6463/

THE MASTER CLEANER

* blankets heat and light

The greatest enemy of efficient production—DUST, whether it is creating a fire risk, damaging machinery, blanketing heat and light, jeopardising health, ruining paint or causing extra labour can, unknown to you, gradually whittle down your profits. You cannot SEE the NEED—but it is there all the same. Eliminate dust with NEW WELBECK industrial suction cleaners—the most advanced and efficient machine on the market today. Your premises need NEW WELBECK to restore lost profits.

Write now for further information to DEPT. 34.

WE SERVE THE LEADERS OF INDUSTRY

I.C.I. use NEW WELBECK industrial suction cleaners.
The 'DUPLEX' model cleaner in use at one of I.C.I.s Alkali Division boiler houses.

By appointment to H.M. The Queen Suppliers of Vacuum Cleaners

NEW WELBECK LTD.

HEAD OFFICE & WORKS: Moulsecoomb Way, Brighton, 7, Sussex
Tel.: Brighton 61666 (PBX)

LONDON OFFICE: 6 Cavendish Square, London, W.1
Tel.: LANgham 1517 (PBX)

BRANCHES AT BIRMINGHAM, MANCHESTER, SCOTLAND & EIRE

HEAVY TRANSPORT

MARINE DIESELS

AIRCRAFT

MINING MACHINERY

EARTH MOVING

MACHINE TOOLS

Think of the clutch

"In . . . . . Out! *In . . . . . O*

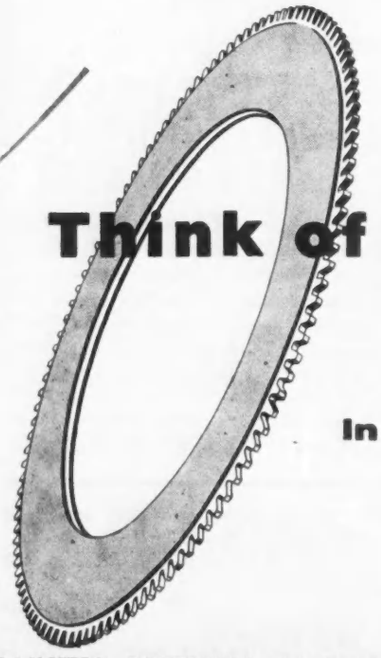
You can almost hear the Boat Race commentat voice intoning the repetitive action that wears o the crews in some twenty minutes.

And so with clutch plates. The punishing friction inseparable from repeated engagements of the clutch inexorably wears out the normal type of clutch plate, with regrettable speed. Result—costly idle time for refacing or replacement.

But this is not so with SINTERLINK clutch plates. Faced with sintered metal of cellular structure, they stand up to a tremendous amount of friction for very much longer than conventional clutch plates. The exceptional resistance to wear of SINTERLINK and its remarkable ability to withstand and dissipate heat are the explanation.

Any Answers?

We will gladly answer any questions either by correspondence or by personal call.



Think of MORGAN SINTERLIN

the final factor in Power Transmission

MAXIMUM MARKS TO SINTERLINK FOR

Low Rate of Wear · Smooth Operation
Stability · Absence of Fade
High Thermal Conductivity

THE MORGAN CRUCIBLE COMPANY LIMITED, BATTERSEA CHURCH ROAD, LONDON, S.W.11 Tel: BATTERS

M126/A

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.

Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.

Inch Rate. 42/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £22. ½-page £41 10s. Full page £78.

Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Box Number. 2/-, which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

Advertisements for publication should be addressed to:— **Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

NOTTINGHAM AND DISTRICT TECHNICAL COLLEGE

SHAKESPEARE STREET, NOTTINGHAM

Principal: D. A. R. CLARK, M.Sc. (Tech.), M.I.Mech.E.

APPOINTMENTS

Due to the increase in the volume of advanced work, the following additional appointments to the full-time Teaching Staff are required for September next. The College will, in the main, concentrate in future on post-Ordinary National Certificate and post-Intermediate City and Guilds work. A large, new building costing approximately one million pounds will come into full use in September next and will provide accommodation for well-equipped departments of Building and Civil Engineering, Electrical Engineering, Chemistry, Physics and Mathematics, and Mining. Increased accommodation is also available to the Departments of Mechanical Engineering, Arts and Commerce, Printing and Textiles. Research work by both staff and students is being rapidly developed. College senior teaching staff will be expected to undertake or supervise research work. Consultancy work by staff is encouraged.

Industrial experience, teaching experience and research experience will all be of considerable advantage to the selected candidate.

SENIOR LECTURER IN MACHINES AND MACHINE DESIGN.

SENIOR LECTURER IN BUILDING MATERIALS.

LECTURER IN THERMODYNAMICS.

LECTURER IN CIVIL ENGINEERING.

Salaries in accordance with the Burnham Technical Scale, as follows: Senior Lecturer: £1350, rising by annual increments of £50 to £1550 per annum; Lecturer: £1200, rising by annual increments of £30 to £1350 per annum.

Further particulars and form of application may be obtained from the Principal, to whom completed forms should be returned not later than 16th May, 1958. E7024

WARRINGTON EDUCATION COMMITTEE

TECHNICAL COLLEGE

LECTURER IN MECHANICAL ENGINEERING

LECTURER IN MECHANICAL ENGINEERING required in September, 1958. Candidates will be required to teach to H.N.C. two of the following subjects:—

Structures, Hydraulics, Materials, Machines.

Salary: Burnham Scale, £1200 by £30 to £1350. Approved industrial experience qualifies for increment within the scale.

Application forms and further particulars may be obtained from the Chief Education Officer, Education Office, Bewsey Street, Warrington, upon receipt of a stamped addressed, foolscap envelope, and should be returned as soon as possible. E6983

FOURAH BAY COLLEGE— SIERRA LEONE

(UNIVERSITY OF DURHAM)

MILL LECTURESHIP IN ENGINEERING

Applications are invited for appointment to the above LECTURESHIP. The Lectureship is tenable by a Mechanical, Civil or Electrical Engineering but in the present appointment ability to teach Electrical Engineering would be an advantage. Candidates should be Graduates in Engineering with some teaching or research experience.

The appointment is on contract for up to five years. Salary: £965 by £50 to £1415 by £75 to £1715. Initial salary according to qualifications and experience. Other conditions include children's allowances (maximum £300), passages on appointment and annual leave, part-furnished accommodation at rental not exceeding 7½ per cent of salary.

Further information may be obtained from the Council for Overseas Colleges, 12, Lincoln's Inn Fields, London, W.C.2, to whom applications (six copies), giving age, full particulars of qualifications and experience, and naming three referees, should be sent by 20th May, 1958. E7017

PUBLIC APPOINTMENTS

CITY OF BIRMINGHAM EDUCATION COMMITTEE

MATTHEW BOULTON TECHNICAL COLLEGE

SUFFOLK STREET, BIRMINGHAM, 1

Principal:
J. C. MARTIN, M.A., A.M.I.E.E., A.M.Brit.I.R.E.

APPOINTMENTS

Applications are invited for the following full-time teaching posts to commence duty on the 1st September next. Application forms and particulars may be obtained from the Principal (s.a.e.), and should be returned to him within 14 days of the appearance of this advertisement.

Salary scales in accordance with the Burnham (Further Education) Report, 1956:—

LECTURER: £1200 by £30 to £1350.

Candidates may be granted additional increments above the minimum and up to the maximum of the above scale in accordance with their industrial, professional or research experience as approved by the Authority as of equivalent standard.

ASSISTANT GRADE "B": man, £650 by £25 to £1025; woman, £580 by £20 to £820, plus equal pay increments.

Candidates may be granted additional increments above the minimum of the above scale for time spent in industry, commerce, professional work or research. There are also additions to the scale for a Degree or equivalent professional qualifications.

Lecturer, to take charge of Applied Mechanics and Heat Engines Laboratories for work up to Ordinary National Certificate level.

Assistant Grade "B," to teach up to Ordinary National Certificate and City and Guilds Intermediate level in Mechanical Engineering.

E. L. RUSSELL,
Chief Education Officer.
E7033

FOURAH BAY COLLEGE— SIERRA LEONE

(UNIVERSITY OF DURHAM)

SENIOR LECTURER IN ENGINEERING

Applications are invited for appointment to the post of SENIOR LECTURER IN ENGINEERING. The post is newly-created in connection with the courses about to be established in General Engineering Technology.

Qualifications: Degree in Engineering, preferably Mechanical; Associate Membership of an Engineering Institution; good teaching experience to Degree level essential. The person appointed will be Head of the Department of Engineering and will be responsible to the Principal for the conduct of the Engineering Coursing.

Salary: £1700 by £75 to £2150. Entry point according to qualifications and experience. Other conditions include children's allowances (maximum £300), passages on appointment and annual leave, part-furnished accommodation at rental not exceeding 7½ per cent of salary.

Further information may be obtained from the Council for Overseas Colleges, 12, Lincoln's Inn Fields, London, W.C.2, to whom applications (six copies), giving age, full particulars of qualifications and experience, and naming three referees, should be sent by 20th May, 1958. E7019

BRADFORD INSTITUTE OF TECHNOLOGY

(COLLEGE OF ADVANCED TECHNOLOGY)

Principal: E. G. EDWARDS, Ph.D., B.Sc., F.R.I.C.

SENIOR LECTURER

Applications are invited for appointment of SENIOR LECTURER in the Department of Mechanical Engineering. Applicants should be Graduates, and Corporate Membership of a Professional Institution is desirable.

The salary scale for men, in accordance with the Burnham Technical Award, is from £1350 to £1550 per annum.

Previous industrial or research experience at a suitable level may be taken into account in fixing the commencing salary.

Further particulars and forms of application may be obtained from the Principal, Institute of Technology, Bradford, 7.

W. H. LEATHEM,
Clerk to the Governors.
E6986

PUBLIC APPOINTMENTS

ESSEX EDUCATION COMMITTEE

SOUTH-WEST ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART

FOREST ROAD, WALTHAMSTOW, LONDON, E.17

ENGINEERING DEPARTMENT

APPOINTMENTS

As a result of continued expansion in the Engineering Department, the following posts will be available from 1st September, 1958:—

(a) LECTURER IN ELECTRICAL ENGINEERING, to teach Electronics and Electrical Theory and Measurements up to the standard of Final B.Sc. (Eng.). Applicants should hold a Degree in Electrical Engineering and have suitable teaching and industrial experience.

(b) LECTURER IN MECHANICAL ENGINEERING, to teach Mechanics of Fluids and Applied Thermodynamics or Mechanics of Machines. Applicants should be Graduates and/or Associate Members of the Institution of Mechanical Engineers. Some teaching and industrial experience is desirable.

(c) ASSISTANT GRADE B IN PRODUCTION ENGINEERING, to lecture in Metrology to Higher National Certificate level, and Workshop Techniques to Final City and Guilds level. Candidates should be Associate Members of the Institution of Production Engineers, or be otherwise suitably qualified. Practical experience essential.

(d) ASSISTANT GRADE B, to teach Engineering Workshop Practice, Technology and Science to Final City and Guilds level in Machine Shop Engineering and to Engineering Trade Apprentices. Higher National Certificate or equivalent required with good industrial experience in mechanical engineering.

(e) ASSISTANT GRADE B, to teach Motor Vehicle Work for City and Guilds Motor Vehicle Mechanics' and Technicians' courses. Teaching and practical experience desirable.

(f) ASSISTANT, GRADE B, to teach Light Electrical Engineering subjects, Radio and Television Servicing, for Higher National Certificate and City and Guilds courses. Higher National Certificate or Full Technological Certificate and practical experience desirable.

Salaries: Lecturers, £1200 by £30 to £1350, plus London allowance (£36 or £48 p.a.); Assistants Grade B, £650 by £25 to £1025, with additions for Degree or equivalent and approved training. Increments within scale for previous teaching service, approved industrial experience and war/national service. London allowance payable (£36 or £48 p.a.).

Applications (no forms) by letter, giving particulars of qualifications, training and experience, and enclosing copies of three recent testimonials, or giving the names and addresses of three referees, to be submitted to the Clerk to the Governors at the College. E7034

WELSH COLLEGE OF ADVANCED TECHNOLOGY

Principal: A. HARVEY, Ph.D., B.Sc., F.Inst.P.

ENGINEERING DEPARTMENT

LECTURERS

Applications are invited for the following posts:—

(a) LECTURER IN PRODUCTION ENGINEERING. Salary: £1200 by £30 to £1350 p.a.

Applicants should be at least Graduate Members of the Institution of Mechanical Engineers and the Institution of Production Engineers, and have had sound industrial experience.

(b) TWO SENIOR LECTURERS IN MECHANICAL ENGINEERING. Salary: £1350 by £50 to £1550 p.a.

(c) ASSISTANT LECTURER, Grade B, in MECHANICAL ENGINEERING. Salary: £650 by £25 to £1025 p.a., plus additions for training and Degree.

Candidates should be University Graduates in Mechanical Engineering and have had industrial or research experience; they should be (at least) Graduates of the Institution of Mechanical Engineers.

Further particulars and forms of application may be obtained from the Principal, Cathays Park, Cardiff, and forms should be returned not later than 17th May, 1958.

ROBERT E. PRESSWOOD,
Clerk to the Governors.
April, 1958. E7010

PUBLIC APPOINTMENTS

FOURAH BAY COLLEGE— SIERRA LEONE

(UNIVERSITY OF DURHAM)

LABORATORY SUPERINTENDENT

Applications are invited for appointment as LABORATORY SUPERINTENDENT for the Engineering Laboratories of the College. Qualifications: considerable experience as Engineering Laboratory Technicians, preferably in a University or College of Technology.

The appointment is on contract and carries a salary of £660 by £30 to £720; £810 by £36 to £990; £1032 by £42 to £1116, plus 10 per cent with, in the case of overseas candidates, an allowance of £240 per annum on a salary of up to £975 inclusive and £270 per annum on a salary of £976 to £1116. Other conditions include children's allowances (maximum £300), a gratuity, passages on appointment and annual leave, and part-furnished accommodation at rental not exceeding 7½ per cent of salary.

Further information may be obtained from the Council for Overseas Colleges, 12, Lincoln's Inn Fields, London, W.C.2, to whom applications (six copies), giving age, full particulars of qualifications and experience, and naming three referees, should be sent by 20th May, 1958. E7018

UNIVERSITY OF LONDON KING'S COLLEGE

DEPARTMENT OF CIVIL ENGINEERING

LECTURER

Applications are invited for the post of LECTURER IN CIVIL ENGINEERING, vacant on 1st October, 1958.

Applicants should have an Honours Degree and professional experience. Special interest in concrete structures will be an advantage. Salary on the scale £900 by £50 per annum to £1350 and then by £75 per annum to £1650, plus £60 per annum London allowance, with starting point according to qualifications and experience. Family allowances and F.S.S.U. benefits will be payable.

Conditions of appointment and application forms may be obtained from the Registrar, King's College London, Strand, W.C.2. Completed forms must reach him by May 20th, 1958. E6922

UNIVERSITY OF MANCHESTER

LECTURER IN ENGINEERING (MECHANICAL)

Applications are invited for two posts of LECTURER IN ENGINEERING (MECHANICAL). For one post a prime interest in thermodynamics applied to heat engines is required; for the other interests in applied thermodynamics, heat transfer, mechanisms or machine design. University regulations permit teaching staff to read for the Degrees of M.Sc. and Ph.D. The salary scale is £900 to £1650 per annum. Membership of the F.S.S.U. and Children's Allowance Scheme. Initial salary according to qualifications and experience.—Applications should be sent not later than May 24th, 1958, to the Registrar, The University, Manchester, 13, from whom further particulars and forms of application may be obtained. Applications by airmail (no forms) will be considered from overseas candidates. E6994

BRITISH RAILWAYS

WESTERN REGION

TECHNICAL ASSISTANTS

Applications are invited for posts of TECHNICAL ASSISTANTS experienced in design of steel concrete bridges and able to prepare detailed drawing and estimates. Workshop training an advantage. Salary range £809/£877.

Travel concessions, holidays with pay, with prospects of promotion and permanency with membership of superannuation fund.

Applications, stating age, previous experience, &c., to Chief Civil Engineer, B.R. Western Region, Paddington Station, London, W.2. E6956

Classified Advts. continued on page 126

PUBLIC APPOINTMENTS

MERSEY RIVER BOARD

ASSISTANT AREA ENGINEER

Applications are invited for the appointment of ASSISTANT AREA ENGINEER, Eastern Areas of the Board. Applicants must be Chartered Civil Engineers with considerable experience in river work.

The salary will be in accordance with A.P.T. Grade V (£1175 to £1325). The commencing salary will depend upon qualifications and experience.

The applicant must be able to drive a motor-car and live within reasonable distance of the Board's area office at Sale, Cheshire.

The appointment, which may be terminated by one month's notice on either side, is subject to the Local Government Superannuation Acts.

Applications, stating age, education, qualifications and experience, together with two references, should be sent to J. T. Firth, B.Eng., M.I.C.E., Engineer to the Board, at the address given below, to arrive not later than the 16th May, 1958.

A. H. JOLLIFFE,
Clerk of the Board.

Liverpool Road,
Great Sankey,
Warrington. E7028

MANCHESTER CORPORATION WATERWORKS

ASSISTANT ENGINEERS (CLASS III)

Applications are invited for the undermentioned engineering appointments on the temporary staff of the Corporation in connection with the design and execution of works included in (a) the Third and Fourth Instalments of the Haweswater Scheme, including the laying of 54in dia. steel pipes, and the construction of two service reservoirs (200 million gallons capacity), near Bury, Lancs, and (b) the filtration and treatment of the Longdendale supply :

ASSISTANT ENGINEERS (CLASS III). Salary in the range of £575/£845 p.a., according to qualifications and experience.

Applications, stating (1) age, (2) education and training, (3) professional qualifications, (4) experience in the preparation of plans and construction of waterworks or other civil engineering works, together with the names of two referees, should be addressed to the Engineer and Manager, Waterworks Offices, Town Hall, Manchester, 2, so as to be received by 10th May, 1958. E6864

GOVERNMENT OF RHODESIA AND NYASALAND

DEPARTMENT OF CONSERVATION AND EXTENSION

VACANCY : CONSERVATION ENGINEER

Applicants must hold a Degree in Civil Engineering, or A.M.I.C.E. or equivalent. Experience in soil and/or water conservation work, hydrology and particularly land drainage advantageous but not essential.

Starting Salary : £1700 per annum on scale £1700 by £50 to £1850. Promotion to senior posts depends on vacancies and efficiency.

Duties : Will include research on aspects of soil and water conservation, erosion control and hydrology (essentially with problems of land drainage).

Application forms and further details from Secretary (R), Rhodesia House, 429, Strand, London, W.C.2. Closing date June 6th. E7037

FOUNTAIN GROUP HOSPITAL MANAGEMENT COMMITTEE

SUPERINTENDENT ENGINEER

Applications are invited for the appointment of SUPERINTENDENT ENGINEER at the Fountain Hospital, Tooting Grove, London, S.W.17. Salary, £790, rising to £925 per annum, plus London weighting. Resident post. Accommodation available.

Applicants should have completed an apprenticeship in mechanical engineering or have otherwise acquired a practical training in mechanical engineering as distinct from a purely craft training. They must also hold a First Class Certificate of Competency in Marine Engineering (or equivalent Naval Certificate), or an approved equivalent qualification which includes Heat and Heat Engines and an endorsement in the Principles of Electricity.

Applications, stating age, qualifications and experience, and names of two referees, to the Group Secretary, Fountain Hospital, as soon as possible. E6969

GOVERNMENT OF UGANDA

SUPERINTENDENT OF APPRENTICESHIP AND TRADE TESTING

SUPERINTENDENT OF APPRENTICESHIP AND TRADE TESTING, preferably between 37 and 47, required to take charge of Apprenticeship and Trade Testing Division of Labour Department, and to supervise and advise on apprenticeship training in industry and Government Departments. Considerable practical experience and first-hand knowledge of apprenticeship training, also administrative ability essential. Degree in Engineering or equivalent professional qualification or appropriate engineering experience in Her Majesty's Forces necessary. Post on contract/resettlement grant terms for one tour of 30–36 months. Home pension rights preserved. Salary at appropriate point in scale £939 to £1863 inclusive. Quarters, when available, at low rental. Free passages and medical attendance. Outfit, education and separation allowances. Generous home leave. Low income tax.—Further particulars and application forms obtainable from Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD.132/9/06. Closing date for receipt of initial enquiries 31st May, 1958. E7032

PUBLIC APPOINTMENTS

LEE CONSERVANCY CATCHMENT BOARD

APPOINTMENTS

Applications are invited for :—

(a) ONE ASSISTANT ENGINEER (Temporary), within the range of Grades II–III (£730–£1030 per annum, plus London weighting), according to experience and qualification.

(b) THREE ENGINEERING ASSISTANTS, within the range of Grades I–II (£580–£850 per annum, plus London weighting), according to experience and qualifications.

Applicants for appointment (a) should be Corporate Members of the Institution of Civil Engineers or hold other appropriate qualifications, and should have a considerable experience of design and/or supervision of civil engineering work of some magnitude. This appointment is in connection with a major scheme of works which is expected to continue for several years. The works include heavy excavation, bridges, mass, reinforced and prestressed concrete culverts, sewers and ancillary works.

Applicants for appointment (b) should have had experience in the design and supervision of civil engineering works and in one case land drainage experience would be an advantage.

Travelling and subsistence allowances in force from time to time will be payable, and the successful candidates may be required to provide their own cars, in which event they will be entitled to an essential user allowance.

The appointments will be subject to the National Scheme of Conditions of Service for Local Authorities' Administrative, &c., Staffs, and to one month's notice on either side, and the successful applicants may be required to pass a medical examination. Applicants should state whether they would wish to be specified as contributory employees for the purposes of the Local Government Superannuation Act, 1937, and, if so, give particulars of previous contributory and non-contributory service.

Applications, stating age, qualifications, experience, &c., accompanied by copies of three recent testimonials, and endorsed for (a) "Assistant Engineer," and for (b) "Engineering Assistants," should reach N. Medrington, Esq., A.M.I.C.E., M.I.W.E., Engineer to the Board, "The Grange," Crossbrook Street, Cheshunt, Herts, not later than first post on Monday, 2nd June, 1958.

J. L. SPILLER,
Clerk of the Board.

Head Office of the Board
Brettenham House,
Lancaster Place,
Strand,
London, W.C.2. E6971

CITY OF CARDIFF

CORPORATION WATERWORKS

APPOINTMENTS

Applications are invited for the following permanent appointments on the staff of the Water Engineer and Manager.

RESIDENT ENGINEER (A.P.T. IV, £1025–£1175 per annum) at the Corporation Reservoirs and Treatment Works.

Applicants must have had experience on maintenance of catchment area, impounding reservoirs, treatment, pumping plant and trunk mains. Housing accommodation will be available at a reasonable rent.

ENGINEERING ASSISTANT (Special Classes Grade, £750–£1030 per annum).

Applicants must have passed Sections "A" and "B" of the Associated Membership Examination of the Institution of Civil Engineers or possess an Engineering Degree giving exemption therefrom.

General conditions and further details of these appointments can be obtained from the Water Engineer and Manager, City Hall, Cardiff, and applications, stating age, previous experience and qualifications, together with the names of two referees, should reach the undersigned, in envelopes appropriately endorsed, not later than Tuesday, the 20th May, 1958.

S. TAPPER JONES,
Town Clerk.

City Hall,
Cardiff,
28th April, 1958. E7035

CITY OF PLYMOUTH

APPOINTMENT OF SPECIAL STAFF FOR BRIDGE DESIGN AND CONSTRUCTION

Applications are invited for the following appointment :

SENIOR ENGINEER in Grade B (£1270–£1440), for the design and the supervision of the construction of the proposed new Laira Bridge. This is a 500ft. long dual carriageway crossing of tidal water and involves deep foundation.

Applicants should be qualified civil or structural engineers with experience in reinforced and prestressed concrete design and also in deep foundation work.

It is anticipated that the appointment will, subject to satisfactory service, be for a period of 4 years, the first part of which will be spent on design and the preparation of contract documents and the remainder as Resident Engineer.

Age limit 40 or 45 if already serving with a Local Authority. The appointment is subject to medical examination and the successful applicant will be required to contribute to the superannuation fund.

Housing accommodation, if required, will be made available for a period of 12 months and part of removal expenses refunded.

The starting salary will be fixed within the grade according to qualifications.

Applications on forms obtainable from me are returnable within 14 days of the appearance of this advertisement.

J. PATON WATSON, C.B.E., M.I.C.E.,
City Engineer and Surveyor.

The Guildhall,
Plymouth. E6957

PUBLIC APPOINTMENTS

WAR DEPARTMENT

BULFORD

CLERK OF WORKS (MECHANICAL)

CLERK OF WORKS (MECHANICAL) required by War Department at Bulford. Applicants must be of British parentage and possess following qualifications. Ordinary National Certificate in Electrical and/or Mechanical Engineering or evidence of equivalent standard of technical education ; and five years' apprenticeship or equivalent with an engineering concern giving good comprehensive training. Completion of course at School of Military Engineering required for appointment to Establishment for Engineer Services as Clerk of Works (Mechanical) constitutes equivalent qualification. In addition, must have the following experience : (i) After completing apprenticeship at least three years with engineering firm giving good comprehensive experience, or (ii) three years' service as Supervisor of Labour, Chargehand or Technical Officer in Engineering Industry. Salary will be assessed according to age, qualifications and experience, on provincial range of £655 (at age 26) to £820 per annum. Posts are temporary but with long-term possibilities.

Application to :—
Chief Engineer,
H.Q. 1 Div./Salisbury Plain District,
Bulford Camp,
Bulford,
Wilts. E6952

THE BRITISH TRANSPORT COMMISSION

SOUTH WALES DOCKS

ENGINEERING ASSISTANT

The British Transport Commission invite applications for appointment as ENGINEERING ASSISTANT on the staff of the Civil Engineer, South Wales Docks. Salary ranges between £916/£1120 per annum.

Applicants should have experience in the design and construction of general civil engineering works, preferably with knowledge of maritime works, but this is not essential ; should be able to prepare estimates of cost and contract documents. They should be Corporate Members of the Institution of Civil Engineers or qualified for election. Certain free travel facilities, superannuation scheme, good prospects for selected candidates.

Applications, stating age, experience and qualifications, should be sent to the Chief Docks Manager South Wales Docks, Pierhead Building, Cardiff. E6973

PUBLIC WORKS DEPARTMENT HONG KONG

MECHANICAL ENGINEER

To supervise and maintain all waterworks mechanical equipment, including pumping station, filtration plant and a workshop employing 150 men. Specification ordering and installation of new mechanical equipment.

Pensionable appointment in the salary range £1245–£2178, plus a variable cost-of-living allowance. Quarters, if available, at low rental. Free medical attention and free passages for officer and family. Generous leave. Low taxation.

Candidates must be A.M.I.Mech.E. and under 35 years of age. They should have served an apprenticeship or post-graduate pupillage with a manufacturer of heavy equipment, preferably waterworks type pumping plant. They should have varied experience of this type of plant and like duties involving familiarity with substantial equipment. Training and experience with a water supply authority acceptable. —Write, Director of Recruitment, Colonial Office, London, S.W.1, stating age, qualifications and experience. Quote BCD.112/51/024. E6996

CIVIL SERVICE COMMISSION

SENIOR SCIENTIFIC OFFICERS : SCIENTIFIC OFFICERS

SENIOR SCIENTIFIC OFFICERS (a) ; SCIENTIFIC OFFICERS (b). Pensionable posts for men and women in major scientific fields, including Meteorology and Geophysics (frequent overseas surveys). A few vacancies for BIOLOGISTS, including specialised posts in Taxonomy of Invertebrate Animals, Taxonomic Entomology, Fungus Systematics and Plant Pathology, and one post for a TAXONOMIC BOTANIST (Pteridophyta).

Qualifications : normally first or second-class Honours Degree in Science, Mathematics or Engineering, or equivalent attainment ; additionally, for (a), at least 3 years' relevant (e.g. post-Graduate) experience. Normal age limits : (a) between 26 and 31 ; (b) between 21 and 28, with extensions for regular Forces service and Overseas Civil Service. London salaries (men) : (a) £1190–£1410 ; (b) £635–£1110. Five-day week generally.

Write, Civil Service Commission, 30, Old Burlington Street, London, W.1, for application form, quoting (a) S.53/58 ; (b) S.52/58. E7020

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent. successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E721 ■

FREE ! Brochure giving details of Courses in Mechanical and Production Engineering, Draughtsmanship, &c., for the A.M.I.Mech.E., A.M.I.P.E., City and Guilds and other professional examinations. —E.M.I. Institutes, Dept. E.30, London, W.4. (Associated with H.M.V. E972 ■

PUBLIC APPOINTMENTS

ADEN PORT TRUST

ASSISTANT MAINTENANCE SUPERINTENDENT

The Board of Trustees invite applications for the post of ASSISTANT MAINTENANCE SUPERINTENDENT, not more than 36 years of age, who should have served a recognised engineering apprenticeship and should possess a First Class Certificate of the Ministry of Transport Marine Engineers Examinations. Preference will be given to candidates who hold a First Class Steam and Diesel Certificate, but candidates with workshop experience since qualifying as Engineers dates will be considered for a higher salary.

Salary of the appointment is £1950 per annum under agreement. Free quarters and medical attention. Contributory pension fund.

For full details apply to Personnel Department, Engineering Engineers and Agents, Aden Port Trust, 3, Lowndes Place, Grosvenor Gardens, London, S.W.1 (Tel. No. Sloane 3433).

TENDERS

LEE CONSERVANCY CATCHMENT BOARD

FLOOD ALLEVIATION SCHEME

CONTRACT NO. 1

TENDERS are invited from competent contractors for the CONSTRUCTION, in the Borough of Chingford, in the County of Essex, of a [illegible] BRIDGE, approximately 70ft. long over all and 30ft. wide, to carry the Chingford Branch of the Eastern Region of British Railways (E.R.) over a flood relief channel between Clapton and St. James' Street.

The works include abutments and wing walls of reinforced concrete, wing walls and [illegible] 250ft. of flood channel in mass concrete, [illegible] spans partly encased in concrete, and [illegible] embankment ; these works must be carried out without interference with the work of the railway except during short periods of possession.

Instructions to tenderers and documents will be available on or after 1st May, 1958, from Messrs. Palmer and Tritton, 125, Victoria Street, London, S.W.1, on payment of £20 deposit made payable to the order of the Lee Conservancy Catchment Board and returnable under certain conditions.

On or after 1st May, 1958, documents may be inspected at the offices of Messrs. Palmer and Tritton, at the above address, without payment.

Tenders to be delivered to the undersigned by 12 o'clock noon (B.S.T.) on 2nd June, 1958.

J. L. SPILLER,
Clerk of the Board.

Lee Conservancy Catchment Board,
Brettenham House,
Lancaster Place,
Strand,
London, W.C.2.

CITY OF NOTTINGHAM

WATER DEPARTMENT

ANNUAL CONTRACTS—[illegible]

CAST-IRON PIPES—Classes "C" [illegible] (including ordinary sand cast, and [illegible] iron).

SPECIAL CASTINGS up to and including Class "CD."

SPECIAL CASTINGS over 6in.—Class "CD."

IRREGULAR SPECIAL CASTINGS—Class "CD."

MISCELLANEOUS IRON CASTINGS.

HYDRANTS AND SLUICE VALVES.

GUN METAL FITTINGS.

Nottingham Corporation invite Tenders for the SUPPLY of the above STORES MATERIALS, for the 12 months ending 30th [illegible]

Copy of the General Conditions, Specification, Forms of Tender, &c., for any of the contracts mentioned will be forwarded on application to B. W. Davies, Engineer and General Manager, Water Department, Castle Boulevard, Nottingham.

Tenders to be sent to me in the envelopes provided not later than noon on Saturday, the 17th May, 1958.

T. J. [illegible]
Town Clerk.

Guildhall,
Nottingham.

EDUCATIONAL

TECHNICAL HOME STUDY COURSES

For A.M.I.Mech.E., A.M.I.Chem.E., A.M.I.M.I., A.F.R.Ae.S., C. & G., &c.

OVER 50 FIRST PLACES and [illegible] Passes have been secured by T.I.G.S. students. **Professional Engineering Examinations** and a **wide range** of exclusive Home Study Courses in **all branches of Engineering**—Mechanical, Civil, **Aeronautical**, Automobile, Chemical, Mining, **and Television**, Draughtsmanship, &c. Courses include **blueprints**, &c., are provided and, if desired, may be paid by moderate instalments. Write (stating subject of interest) for copy of **Prospectus FREE** and without obligation.

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN
(Dept. 76),
29, WRIGHT'S LANE, LONDON

YOU ARE INVITED TO SEND FOR

7 DAYS' FREE EXAMINATION

OF

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MANY NEW TABLES AND NEW FORMULÆ

This standard technical reference on every branch of engineering is now issued in an 8th enlarged Edition. In over 2,000 pages it provides, in compact form, an abundance of information you constantly need—data, tables, formulæ, and technical knowledge always at your elbow. Examine this new edition without obligation by posting coupon to-day!

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Important New Features Include— **Limits and Fits, Runouts for Screw Threads, Screw Threads for Glass Containers, Diamond Tools for Abrasive Wheel Turning, Copying Lathes, etc.**

ACT NOW — POST COUPON TO-DAY!

George Newnes, Ltd, 66-69, Great Queen St., London, W.C.99.

Send ENGINEER'S REFERENCE BOOK without obligation to purchase. I will either return it in 8 days or send 7s. 6d. deposit 8 days after delivery, then eight monthly subscriptions of 10s., paying 87s. 6d. in all. Cash price in 8 days 80s.

Name .....

Address .....

.....

Occupation .....

Your Signature .....

(Or Parent's Signature if under 21) E.B.9

Place X where it applies	
House OWNER	
Householder	
Living with Parents	
Lodging Address	

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED

AN OIL REFINERY PLANT MAINTENANCE SUPERVISOR is required for service in TRINIDAD, B.W.I., with Texaco Trinidad, Incorporated. The position entails the organisation and supervision of maintenance work on furnaces, vessels, heat exchangers, piping, and other oil refinery plant.

Applicants for this pensionable position should have served an apprenticeship and have the Higher National Certificate in Mechanical Engineering. They should have experience of similar work, preferably in the oil or chemical industries, and be aged 25–30.

Please write, with brief particulars, to the Personnel Officer, Trinoil (U.K.), Limited, Trinidad House, Old Burlington Street, London, W.1. E6942 A

APPLICATIONS ARE INVITED for the following appointment at the CLAYDON, SUFFOLK, Works of THE BRITISH STEEL PILING CO., LTD.:—

SENIOR DESIGNER : DRAUGHTSMAN (minimum qualifications H.N.C. or equivalent).

Age group 28–35 years. Candidates should be capable of accepting responsibility for complete projects.

THIS APPOINTMENT IS PERMANENT AND PROGRESSIVE IN AN EXPANDING ORGANISATION, and the successful candidate will be engaged on interesting work in connection with special crane type structures, hoisting machinery (steam, diesel, electric) and contractors' plant.

Contributory pension scheme in operation. Good canteen facilities. Salary in accordance with qualifications and experience. The works are situated 15 minutes' bus ride from the centre of Ipswich.—Applications to the Personnel Officer at the above address. E6886 A

APPLICATIONS are invited for a position as DESIGN ENGINEER in the "SPECIAL SERVICE" SECTION of the ENGINEERING DEPARTMENT, EAGLE STAR INSURANCE CO., Ltd., 15/25, Ewell Road, Cheam, Surrey.

Candidates should be between 28–32 years, having served a full apprenticeship, with a Higher National Certificate, and be experienced in the design of pressure vessels and structures ; also conversant with modern methods of fabrication. Commencing salary £850 per annum.

Applications to CHIEF ENGINEER at the above address. E1838 A

ASSISTANT CHIEF DRAUGHTSMAN required by old-established and progressive Engineering Company in the Midlands. The company manufactures special machines for various industries, also iron castings, steel fabrications and forgings for general engineering, and employs over 400. Applicants, age 35/45, must have good general engineering experience at least H.N.C., and ability to control drawing-office staff of 30. The appointment carries good salary, pension scheme and early promotion to Chief Draughtsman. Assistance with housing would be considered. Applications must give details of age, experience, education and qualifications, and will be treated in strict confidence.—BOX No. E1835, "The Engineer." A

ASSISTANT TO SALES MANAGER (ENGINEERING)

North-Western firm have a vacancy for a qualified Engineer who has a minimum of two years' experience after graduation on medium/heavy mechanical engineering work, preferably concerned with Steel Works Plant.

Preferred age 25–30. Applications, with full particulars of education and experience and salary required to the Personnel Manager.—BOX No. E7026, "The Engineer." A

BAKER PERKINS, LIMITED,
require a
GRADUATE ENGINEER
to train for
TECHNICAL SALES REPRESENTATION

THIS POST OFFERS EXCEPTIONAL OPPORTUNITIES OF STEADILY INCREASING RESPONSIBILITY AND RAPID ADVANCEMENT.

Applicants should be in their late twenties or early thirties, but young men graduating this year will be considered. They should possess drive and determination coupled with the qualities of personality which would enable them to make good contacts with customers at all levels. Knowledge of laundry and dry cleaning machinery would be an advantage but is not essential.

The length of training to be given will depend on the capabilities of the selected candidate. It is expected, however, that he should be able to take his place as a fully qualified technical sales representative within twelve months of joining the Company's service.

Initial starting salary will depend on experience and qualifications. Subsequent remuneration, however, will depend entirely on merit and the progress of the man concerned. The Company provides first-class conditions of employment, including contributory pension, life assurance and profit sharing schemes.

Applications, which will be treated in strict confidence, should give full particulars of age, qualifications and experience, and should be sent to the Personnel Manager, Baker Perkins, Limited, Westwood Works, Peterborough. E7025 A

ASSISTANT ELECTRICAL ENGINEER, aged 25–30 years, with experience of lighting and power schemes and MV distribution, required for varied work in Westminster office of consulting engineers. Staff canteen and pension fund available. Preference given to applicants with H.N.C.—Details and salary required to Staff Officer, Rendel, Palmer and Tritton, 125, Victoria Street, S.W.1 (Victoria 8494). E6954 A

ASSISTANT INSTRUMENTATION ENGINEER, experienced in the design and supervision of major electropneumatic installations in connection with the chemical and oil refining industry. This position carries long-term prospects. Commencing salary up to £1250 per annum. Please reply, giving full details of experience and qualifications.—BOX No. E7043, "The Engineer." A

COMMISSIONING ENGINEER, aged 35 to 50 years, with wide experience of commissioning of power station plant or similar heavy industrial plant. To be responsible to Chief Engineer for formulating and implementing a comprehensive commissioning programme for complete nuclear power station. Must be willing to travel and capable of accepting major responsibility. This is a senior and pensionable post. Minimum qualification: A.M.I.Mech.E., A.M.I.E.E., or equivalent.—Applications, giving age, details of education, qualifications and experience, to Chief Resident Engineer, The General Electric Company, Ltd., Hunterston Nuclear Generating Station, West Kilbride, Ayrshire. E6914 A

CONSTRUCTORS JOHN BROWN, LTD., require immediately a PLANT AND TRANSPORT MANAGER for a Plant Depot overseas. Applicants must have had experience of repair and overhaul of all types of pipeline equipment, contractors' plant and transport, and be fully conversant with the administration of a plant depot. A generous salary, free messing, single accommodation and medical attention will be provided.—Reply, giving full details, to Personnel Manager, Constructors John Brown, Ltd., 73, South Audley Street, London, W.1, quoting Ref. E.9629. E6979 A

DANIEL ADAMSON & COMPANY LIMITED

in enlarging the Boiler Section of their business, wish to engage a man of the highest technical ability and qualifications, to take a leading part in the management of their Water Tube Boiler Department.

Please write in confidence to :

The Managing Director at Dukinfield. E7013 A

DESIGNER REQUIRED for modern Rolling Mills and auxiliary equipment.

This post offers every opportunity to the right type of man.

Reply fully, in strictest confidence.—BOX No. E6988, "The Engineer." A

DRAUGHTSMAN required for Development work on special purpose machinery. Wide knowledge of mechanisms essential. Applicants should be aged 21/25 years and have O.N.C. 5-day week. Sick and pension fund.—Apply in writing to Personnel Officer, Osram Glass Works, East Lane, North Wembley. E12 A

DRAUGHTSMAN, experienced fans—dust collectors, fume and dust extraction, &c. Capable of preparing schemes and working on own initiative.—Details of age, education, experience and salary to the Secretary, Prat-Daniel (Stanmore), Ltd., Whitecroft, Nailsworth Stroud, Glos. E1797 A

DRAWING-OFFICE CHECKER wanted, with at least two years' experience. Must have knowledge of Machine Tools and Sheet Metal Machine design and detail.—Write full details to F. J. EDWARDS, LTD., 359, Euston Road, London, N.W.1. E7006 A

ELECTRICAL DRAUGHTSMAN
required by
W. H. ALLEN SONS & CO., LTD.,
BEDFORD
for work on A.C. and D.C. motors and generators.
This is a permanent appointment on interesting work with good prospects.
Generous Pension Scheme.
Assistance towards removal expenses.
Apply in writing, giving full details of experience, to the
PERSONNEL MANAGER,
W. H. ALLEN SONS & CO., LTD.,
BEDFORD. E7008 A

ENGINEERING COMPANY IN WEST AFRICA, importing Electrical Machinery and Equipment manufactured by firms of world-wide repute, requires an ENGINEER capable of developing the sale of these products in a rapidly expanding market. Applicants, who should be under 35, must have had experience in the selling field, backed by a wide practical experience. Qualifications should be at least to H.N.C. Commencing salary will be £1400 per annum. In addition there are family allowances : free furnished accommodation is provided, together with free first-class passages to and from Africa, and free medical attention in Africa. Tours of about 21 months are each followed by substantial leave on full pay. Membership of pension fund. Apply, giving full details of qualifications and experience.—BOX No. E6993, "The Engineer."

Classified Advts. continued on page 128

SITUATIONS VACANT

ELECTRICAL ENGINEER, to take charge of works electrical department. Experience of H.T. and L.T. switchgear and distribution necessary. Knowledge of electric furnaces an asset. Minimum qualifications H.N.C. or equivalent. State age, qualifications and salary required.—BOX No. E1841, " The Engineer." A

ENGINEER REQUIRED by a medium-sized manufacturing company in the Manchester area. Applicants should be under 40 years of age and have as minimum qualifications H.N.C. or equivalent in Mechanical Engineering, drawing-office and practical experience, preferably with rubber machinery, administrative experience and control of staff. The management has a progressive outlook and the post offers an excellent opportunity for further advancement. Good staff conditions, pension and life assurance scheme. Apply, giving full particulars and salary required in first instance.—BOX No. E1833, " The Engineer." A

ESTIMATOR for progressive position with prominent London firm of Land and Marine Boiler Engineers. Drawing-office experience essential ; workshop experience an advantage. Attractive salary commensurate with experience and qualifications. Write fully, stating age, &c.—BOX No. 1645/SE2, c/o Charles Barker and Sons, Ltd., Gateway House, London, E.C.4. E6840 A

FERODO LIMITED, Brake Lining Manufacturers, Chapel-en-le-Frith, have the following vacancies :

1. DRAUGHTSMEN (SENIOR), having experience in Machine Design and Works Layouts, Works Building Design desirable but not essential.
2. SENIOR DIE, JIG AND TOOL DRAUGHTSMAN. Press Tool experience an advantage but not essential. Technical education to at least O.N.C. standard.
3. WORK STUDY ENGINEERS with at least 5 years' experience in Work Study.
4. PROJECT ENGINEERS experienced in Plant Design, Heating, Ventilating, Production Engineering and Plant Layouts ; 30 years of age or over, with H.N.C.

Some assistance will be given with regard to house purchase in cases of successful applicants who are married.—Applicants are invited to submit full details of experience and state age and present salary, to the Personnel Manager. E6901 A

FIRST-CLASS DESIGN ENGINEER required to assist the Technical Director. Must have broad experience of design and calculations in mechanical and structural engineering. Able to supervise and check draughtsmen, and apply practical outlook. Mechanical handling experience an advantage. Apply, with full particulars, stating age and salary required. First-class conditions. Superannuation.—BOX No. E1812, " The Engineer." A

FORD MOTOR COMPANY, LIMITED, have a vacancy in their Power Services for an ENGINEERING ASSISTANT

Applicants should be experienced in the economic operation and maintenance of large industrial E.H.T. generation and transmission systems, with a knowledge of high-pressure steam plant (P.F. fired), auxiliary and control equipment. Knowledge of new plant development will be an advantage. A recognised work's apprenticeship with technical knowledge up to H.N.C. (Elec.) standard is essential. Salary in accordance with experience and qualifications. Non-contributory pension scheme.—Please write to Training and Recruitment Department (O.12 A), Ford Motor Company, Limited, Dagenham, Essex, quoting reference TEP. E6977 A

FORD MOTOR COMPANY LIMITED have vacancies for DRAUGHTSMEN capable of preparing schemes for both High and Low Pressure Water Heating Systems, Air Conditioning and Boiler House Layout and ancillary equipment.

Successful applicants will be responsible for drawing up specifications and schedules of quantities, for scrutinising tenders and progressing contracts. They should be able to work with the minimum of supervision. H.N.C. or membership of I.V.H.E. is desirable but not essential.

Salary according to experience and ability, with participation in a generous non-contributory pension scheme.

Please write to Training and Recruitment Department (012A), Ford Motor Company, Ltd., Dagenham, Essex, giving details of age, experience and qualifications, and quoting reference KHV. E6998 A

GENERAL MANAGER.—Required for Structural Engineering Company, Birmingham area. Must be fully experienced at Management level. Excellent salary with bonus and car. Apply.—BOX No. E1844, " The Engineer." A

JIG AND TOOL ENGINEER required by widely-known medium/heavy engineering company in East Midlands. To be responsible for jig and tool design and production and machine tool maintenance and reconditioning. Fully experienced man required, used to controlling, organising, working under pressure, servicing production of machines and equipments, utilising foundry forge, boiler and fabrication shops, machine shops and fitting and erecting shops. State age, experience, salary.—BOX No. E1834, " The Engineer." A

LLOYD'S REGISTER OF SHIPPING require ENGINEER with Degree or equivalent qualification and preferably marine engineering background. Duties will comprise general investigation into ship and machinery problems, vibration, defects in shafting, gearing, oil engines, turbines, boilers, &c., on board ship, and will necessitate extensive foreign travel. Commencing salary £1100 to £1500, depending on qualifications and experience ; good prospects of advancement.—Apply, giving full particulars, to Secretary, Lloyd's Register of Shipping, 71, Fenchurch Street, London, E.C.3. E6985 A

MANAGING DIRECTOR of Engineering Works with approximately 150 personnel engaged in manufacture of Mining Machinery, due to retire in two years, wishes to appoint man with suitable Engineering and Commercial training, to take over Management. Write, giving fullest details respecting qualifications, experience, age and salary required.—BOX No. E1823, " The Engineer." A

MECHANICAL AND ELECTRONIC ENGINEERS AND PHYSICISTS

BRITISH NYLON SPINNERS LIMITED invite applications from Physicists and Corporate or Graduate Members of the Institutions of Mechanical and Electrical Engineering to keep pace with expansion in their Design, Research and Experimental teams.

The work covers an extensive range of engineering problems. Some can be solved by current techniques but may require original research. Others necessitate fundamentally new ideas.

The problems are concerned with the Development and Automation of Nylon Melt-Extrusion and Yarn Processing and measurement. They include electronic circuit design, precision mechanisms, heat transfer and servo control systems.

Knowledge of the textile industry is unnecessary : more important is the zest and capability for original work which will be done under ideal conditions with up-to-date equipment.

The Company will welcome enquiries, which will be treated in strict confidence and should be addressed to the Personnel Manager, Pontypool, Mon. E7023 A

MATTRESS SPRING MANUFACTURER requires PRODUCTION ENGINEER, to take complete charge of Mattress Spring and Wood Frame Divan Assembly Plant. Prospective applicants requiring further details should apply in writing to the Secretary, Mattress Springs and Components Limited, 77, South Audley Street, London, W.1. E1839 A

MECHANICAL DRAUGHTSMAN. — Large commercial organisation has vacancy in London Head Office for a Senior Mechanical Draughtsman, to take charge of Drawing Office. Preference will be given to applicants who hold a Degree in Engineering and who have had good practical experience in refrigeration, boiler installations and electrical work. Some knowledge of building construction would be an advantage. Permanent, pensionable position with good prospects for the right man. Apply in writing, giving age and details of qualifications and experience. —BOX No. E6945, " The Engineer." A

MECHANICAL ENGINEER, A.M.I.Mech.E. 34/45, required for Iran staff of Rendel, Palmer and Tritton, Consulting Engineers. Experience on pipelines and oil pumping an advantage. Should have some design experience. Salary according to qualifications but not less than £2500 p.a., free of Iranian Income Tax and with free accommodation.—Send fullest particulars to Staff Officer, 125, Victoria Street, S.W.1. E6992 A

QUANTITY SURVEYOR required for service in Tehran as Assistant Superintendent of Technical Services for the National Iranian Oil Company, supervising, estimating, quantity surveying and material supply sections of their office. Qualifications : University Degree or equivalent and Associate Membership of the appropriate Institution, together with experience as a Quantity Surveyor, with estimating, and must have worked in a recognised Quantity Surveyor's Office.

Age 35/45, salary in accordance with qualifications but not less than £2500 free of Income Tax and with accommodation. Two-year tours. Prospects of continuous long-term appointment if satisfactory.

Write fullest particulars to Staff Officer, Rendel, Palmer & Tritton, Consulting Engineers, 125, Victoria Street, London, S.W.1. E6991 A

QUANTITY SURVEYOR OR QUALIFIED CIVIL ENGINEER who has done measurement work, aged 30-35, required in Liverpool area, for site measurements in connection with dock construction works. Salary depends on age and qualifications.—Send fullest particulars to Staff Office, Rendel, Palmer and Tritton, Consulting Engineers, 125, Victoria Street, S.W.1. E6990 A

REQUIRED, ENGINEER, preferably of not more than thirty-five years of age, to understudy managing director and eventually to take complete control of a small jobbing engineering and sheet metal works capable of considerable expansion. The selected candidate will be expected to produce evidence of organising ability and capacity to maintain discipline. —Apply, in confidence, stating salary required, to Managing Director, H. A. Harben and Co., Ltd., Rowlands Works, Kelvin Road, Wallasey, Cheshire. E6964 A

RESEARCH ENGINEER with Degree or equivalent qualifications in Engineering, required for work on development of combustion appliances, controls and instruments for boilers. Programmes include both fundamental research and development work with chance of gaining appreciable industrial experience. Age preferably 20-30 and starting salary within range £560 to £860 per annum. Superannuation and grading schemes. Sports and social club. 5-day week.—Apply in writing to Assistant Secretary, Ref. E.11, B.C.U.R.A., Randalls Road, Leatherhead, Surrey. E7036 A

RESIDENT ENGINEER REQUIRED for mechanical and plant erection work on new oil refinery and chemical plant construction. Should be experienced in use of heavy lifting equipment, pipelines, &c., and control of labour. Commencing salary up to £2000 p.a., according to experience and qualifications. Please write in confidence, giving full details of past employers and contracts carried out.—BOX No. E7045, " The Engineer." A

SENIOR DESIGNER DRAUGHTSMAN with flair for design work, required by small/medium-size engineering firm in South West London, building paper making machinery. Previous experience in this field is not essential but applicants should have qualifications at least equal to Higher National Certificate standard. The work is interesting with opportunities for studying equipment in the field. The prospects are good. Pension scheme. Reply.—BOX No. E7042, " The Engineer." A

SECTION LEADER ELECTRICAL DRAUGHTSMAN and Senior DRAUGHTSMAN required for section handling varied projects, including large plant installations. Section Leader post is a senior staff appointment. Salary commensurate with experience. Interviews arranged to suit applicant.—Write or telephone to Chief Draughtsman, General Engineering Department, Northern Aluminium Company Limited, Rogerstone, Mon. (telephone, Newport 59991/6). E6810 A

SENIOR DRAUGHTSMAN, widely experienced in all types of conveyors, elevators and mechanical handling equipment in the light to medium range. Able to work on own initiative. Excellent salary, 5-day week, pension scheme, &c. Apply.—Modern Mechanisation Limited, 52, Bounds Green Road, N.11. E1832 A

SENIOR MECHANICAL DESIGN ENGINEER

A large industrial engineering company of international repute would be pleased to receive applications from Engineers fully experienced in the mechanical design of petroleum or chemical plants.

The successful candidate should have a good Degree in Mechanical Engineering, combined with a wide experience of the industry.

COMMENCING SALARY UP TO £2750 P.A.

Please write fullest particulars of previous experience, which will be treated in the strictest confidence, to the Managing Director.

BOX No. E7044, " The Engineer." A

SENIOR MECHANICAL ENGINEERING DRAUGHTSMAN required for plant layout and design. General engineering experience desired. Knowledge of rolling mills, conveyors, mechanical handling or furnaces, would be advantageous. Salary commensurate with experience. Interviews arranged to suit applicant.—Write or telephone to Chief Draughtsman, General Engineering Department, Northern Aluminium Company Limited, Rogerstone, Mon. (telephone, Newport 59991/6). E6813 A

SENIOR REINFORCED CONCRETE DESIGNER/DRAUGHTSMAN, experienced in the design of foundations and structures. Top salary. Newly-built semi-detached house available to rent to suitable applicant. Grant towards removal expenses and allowance made until removal effected. Pension and insurance scheme.—Apply, The Power-Gas Corporation, Ltd., Stockton-on-Tees. E7021 A

SENIOR STRUCTURAL DESIGNER OR ARCHITECTURAL DRAUGHTSMAN with experience in reinforced concrete design, required for plant installations, industrial buildings and offices. Salary over £900, according to experience. Interviews arranged to suit applicant.—Write or telephone to Chief Draughtsman, General Engineering Department, Northern Aluminium Company Limited, Rogerstone, Mon. (telephone, Newport 59991/6). E6812 A

SHIFT ENGINEER wanted for oil pumping station on the National Iranian Oil Co. staff in Iran. One year tours because married accommodation not immediately available. Salary £2100 tax free, plus free accommodation. Age 35/40. Diesel experience essential, oil pumping experience an advantage.—Write fullest particulars to Staff Officer,

Rendel, Palmer and Tritton, Consulting Engineers,

125, Victoria Street, London, S.W.1.

E6989 A

STRUCTURAL CIVIL ENGINEER wanted immediately, for large industrial concern in Southern Ireland. Age 25–40. Degree or Associate Membership of Professional Body essential. Sound practical training and experience in design and supervision of erection of structural work common in heavy chemical engineering, specially in steel and reinforced and pre-stressed concrete. Knowledge of aluminium, timber and masonry structure an advantage. Starting salary in range £1000/£1500 per annum, according to qualifications, with generous non-contributory pension scheme and amenities. Reply, giving full particulars in chronological order, of education, training and posts held. Applicants selected for short list may be asked to call for interview at firm's expense.—BOX No. E6927, " The Engineer." A

STRUCTURAL STEELWORK DESIGNER required. Conversant with modern competitive designs.—Applications, stating age, experience and salary required, to Chief Draughtsman, C. & S. Construction Co., Ltd., Worton Road, Isleworth. E7012 A

TAYLOR WOODROW CONSTRUCTION, LIMITED, require an ESTIMATOR experienced in preparing tenders for the construction of oil refinery, chemical and process plants, and pipelines, and capable of taking-off bills of quantities from drawings. Pension scheme. Excellent opportunities for right man.—Write, giving full details of past experience and present employment, which will be treated in strict confidence, to Personnel Manager, Ruislip Road, Southall, Middlesex. E6981 A

TAYLOR WOODROW CONSTRUCTION, LIMITED, require a Senior Chemical and Process Plant DESIGNER-DRAUGHTSMAN, experienced in the layout and detailing of chemical oil refinery and process plant installations, including pipework, steelwork and associated mechanical machinery. Pension scheme. Excellent opportunities for right man.—Write, giving full details of past experience and present employment, which will be treated in strict confidence, to Personnel Manager, Ruislip Road, Southall, Middlesex. E6980 A

TECHNICIAN.—Owing to continued expansion in the Process Engineering Department, a vacancy occurs for a man under 35 years of age with a technical background and possessing at least H.N.C. with an emphasis on Maths. and Physics. The work involves the study of manufacturing processes and the committing of these to the standard process sheet. An opportunity will also arise to carry out investigational work into factory processes and to compile reports in this connection.—Please write, giving full details of age and experience, &c., to the Personnel Officer, Messrs. H. J. Heinz Co., Ltd., Harlesden, London, N.W.10. E7007 A

TECHNICAL ADVISER (Agent Stocki... required by Contractors for Airfield Co... Middle East. Fully qualified and ... flexible pavement constructions. Excellent ... conditions in modern township.—Write ... to BOX E973, I.P.E., Romano House, ... Strand, London, W.C.2.

THE CHESTERFIELD TUBE CO., Chesterfield, Derbyshire, desire to ... DEVELOPMENT ENGINEER ... medium to heavy engineering. Candi... have design and works experience and ... to be responsible for setting to work ... totype plant. The prospects for advance... good for some one with initiative and ... H.N. Certificate or equal is required. Good ... scheme, canteen, &c.—Reply, giving ... experience and salary required, to Chief ... ment Engineer. All applications treated ... fidence.

TOOLROOM SUPERVISOR REQ... man with good practical experience and ... control labour. Previous position in simila... essential. Write, giving particulars of past ex... —BOX No. E1821, " The Engineer."

TRANSLATORS accustomed to handling ... German texts, are invited to contact Brunn... nical Translations, Charlotten-Str., 47, Du... Germany. Must be able to write good ... Please state subjects handled and fees required.

TRINIDAD, B.W.I.—British company ... substantial trading and agency business, ... experienced SENIOR MECHANI... ENGINEER SALESMAN, age 40/45, com... ing salary £2000. Applicants with knowle... steam raising and allied machinery ... experience in a Consulting Engineer's ... should write to BOX " R.B.," c/o J. W. ... & Co., Ltd., 7/8, Great Winchester ... London, E.C.2.

WEST MIDDLESEX FIRM have vac... Light Engineering Section for male ASW... for Progress Control, Material Schedu... tioning, Records, &c. Interesting progr... development work. Write, stating age, ... experience, salary required.—BOX No. ... " The Engineer."

WEST MIDDLESEX FIRM require ... energetic young man for work on ... variety of articles in reinforced fibre glass ... experience an advantage but not essential. ... BOX No. E1814, " The Engineer."

MECHANICAL ENGINEERING DRAUGHTSMAN

required, approximately 23/35 ... of age, with good engineering ... ground and experience in Rub... and Plastic Moulding and Jig ... Tool work. Salary A.E.S.D. ... according to qualifications ... experience. Pension fund, five-... week.—Write, stating age, exp... ence, &c., to the Personnel Offi... British Insulated Callend... Cables, Ltd., Leigh.

APPLICATION ENGINEER

Required for preliminary layout ... and scheduling of oil-firing installa... including selection of suitable ... equipment. Some travelling is incl... since he will supervise commissi... and will hand over the installation ... behalf of the Company.

QUALIFICATIONS AND EXPERIE...
Not important, but an H.N.C. would ... an advantage.
Salary : £800–£1000 per annum.

APPLY :
Technical Manager,
White's of Hebburn (Engineers) Ltd.,
Hebburn on Tyne.

E7002 A

SITUATIONS VACANT

PATENTS OFFICER

SIMON-CARVES LTD.,

...ising in the design and construction of ...industrial plant :—require

A PATENTS OFFICER

...sponsible for patenting new engineering ...scientific developments and to carry ... drafting of patent applications.

...erience of Patents Office work would ... considerable advantage.

...position is permanent and pensionable. ...Starting salary will depend on qualifi...ns and experience.

...brief relevant details to Staff and ...ng Division, Simon-Carves, Ltd., ...e Heath, Stockport, Cheshire, quoting ...K.20.

E6974 A

SITUATIONS VACANT

HEAT EXCHANGERS

Young Engineer required for design, development, and final testing of Heat Exchange equipment for land and marine installations. Candidate need not have experience in this field but should have a good knowledge of the fundamentals of heat transfer and fluid mechanics.

QUALIFICATIONS

Degree or equivalent.

Commencing salary up to £850 per annum.

APPLY :

Technical Manager,
White's of Hebburn (Engineers) Ltd.,
Hebburn on Tyne.

E7003 A

SITUATIONS VACANT

PRODUCTION ENGINEER

Applications are invited for the above position. Candidates should possess a good educational background with sound engineering machine shop experience. Thorough knowledge of modern production methods, coupled with several years' experience in the field of work study will be essential. The successful candidate will be a man who possesses the quality of leadership, initiative and drive. Bonus and pension schemes are in operation.—Apply in confidence, giving fullest particulars of age, educational qualifications, training and appointments held, to the Personnel Manager, Mitchell, Shackleton and Co., Ltd., Vulcan Works, Green Lane, Patricroft, Nr. Manchester.

E6987 A

SITUATIONS VACANT

MECHANICAL ENGINEER

British mining company in South of Spain, have vacancy for Mechanical Engineer, aged under 35 ; free house, superannuation and children's educational allowances ; no income tax ; excellent prospects; university or technical college qualifications essential, and experience in general workshop practice ; must have good electrical knowledge.—Apply in writing, giving full details of qualifications and experience, to the Secretary, The Tharsis Sulphur and Copper Co., Ltd., 136, West George Street, Glasgow, C.2.

E6997 A

PHYSICIST
or
RESEARCH ENGINEER
for
DIRECTORATE OF EXTRAMURAL RESEARCH

THE NATIONAL COAL BOARD supports Scientific Research at Universities, Commercial Research Laboratories, Research Associations and other Agencies. The Directorate of Extramural Research in London is responsible for isolating and formulating problems suitable for study at these Agencies, for progressing the work, and for assimilating and promulgating its results.

Applicants should have a good Honours Degree and substantial research experience ; familiarity with university research is particularly desirable. The successful applicant will conduct technical discussions and negotiations with university professors and research workers, and will assess and report on the results of research. Starting salary at about £2,000 per annum.—Write, giving full particulars, to Staff Dept. (X.1128), N.C.B., Hobart House, Grosvenor Place, London, S.W.1, before 12th May, 1958.

6984 A

BRITISH OXYGEN ENGINEERING LTD.

SITE ENGINEER

Applications are invited for an appointment as a Site Engineer with the Company's Construction Group, entailing responsibility for the erection and installation of large air separation and chemical plant.

Applicants must be qualified engineers with extensive site experience covering mechanical and electrical installations, and be capable of assuming complete control of large sites, including supervision of direct and sub-contract labour. Sites will be located in the U.K. with opportunities for overseas operations.

Applications, giving full details of age, qualifications and experience, to :

The Personal Manager (GH/12)
BRITISH OXYGEN ENGINEERING LTD.
Angel Road, Upper Edmonton, London, N.18.

E7022 A

ELECTRONIC ENGINEER

The English Electric Company, Whetstone, Nr. Leicester, require an Electronic Engineer to help develop a large analogue computer which is used to help solve reactor design problems. This is a first-class opportunity for an Electronic Engineer to enter the nuclear field. Applicants must have experience of D.C. networks, flight simulators or digital computer and preferably a Degree or H.N.C. in Electronic Engineering. Please write, giving full details of age, qualifications and experience, to Dept. C.P.S., 336/7, Strand, W.C.2, quoting ref. E1860B.

NUCLEAR REACTOR DESIGN

E6933 A

IMPERIAL CHEMICAL INDUSTRIES, LIMITED,

Billingham Division

and

Heavy Organic Chemicals Division

Careers for

MECHANICAL ENGINEERS

The new Heavy Organic Chemicals Division of Imperial Chemical Industries, Limited, was formed on 1st January, 1958, and certain of the works of the Billingham Division were taken over. This has meant an increase in the number of Mechanical Engineers required to fill the vacancies resulting from promotions and transfers and to undertake the expansion programme for both divisions.

A wide variety of engineering work is available, and the young engineer will have the opportunity to gain excellent all-round experience. There are immediate vacancies in design, research, work study and management. Post-graduate training on full salary can also be provided for graduates taking up a first appointment this year.

- ★ Attractive salary scheme. Profit-sharing, pension fund, subsidised canteens.
- ★ Assistance with house purchase and removal expenses for married men.
- ★ Substantial lodging allowance for married men for a period of up to six months.
- ★ Excellent social and games facilities.

If you hold a University Degree and are interested in the possibility of an appointment in either division, we invite you to write, giving brief details of age, qualifications and experience, to the Staff Manager, Imperial Chemical Industries, Limited, Heavy Organic Chemicals Division, Billingham, Co. Durham, quoting reference W/S/5.

E6975 A

JOSEPH LUCAS (ELECTRICAL) LIMITED

YOUNG ELECTRICAL AND MECHANICAL ENGINEERS

of Higher National Certificate standard, who are concerned with regard to their future prospects, are invited to apply for positions of Assistant Development Engineers in our development laboratories. The work covers a wide range of problems on new and interesting developments and the positions provide excellent opportunities for advancement. It is desirable that applicants should have served an apprenticeship and have had some previous experience in the design or development of electrical or light mechanical products. The posts are permanent and pensionable. Apply in writing, stating age, qualifications and experience, to the :

PERSONNEL MANAGER, JOSEPH LUCAS (ELECTRICAL) LIMITED, GREAT KING STREET, BIRMINGHAM, 19

quoting reference PM/D/219. E13 A

Classified Advts. continued on page 130

SITUATIONS VACANT

THE HARLAND ENGINEERING COMPANY LIMITED

B.E.P. WORKS, ALLOA, SCOTLAND,

has a vacancy for a

SENIOR METHODS PLANNING ENGINEER

An experienced man is required, with thorough knowledge of modern heavy/medium machine shop practice. Experience in fabrication assembly and jig/Tool design advantageous. Salary range £950–£1100 p.a., according to age and qualifications. Post is permanent and pensionable, and house can be offered if required. Applicants, who should preferably be qualified to H.N.C. Standard, are asked to write in confidence, stating full personal details, to the Works Manager, B.E.P. Works. E7027 A

ENGINEERS FOR MANAGEMENT

- If you are between 30 and 35 years of age, possess a Higher National Certificate in Mechanical engineering, and have had experience, either in a supervisory or a technical capacity in a process industry, we invite you to send us in confidence particulars concerning yourself and your career to date.
- Owing to continued expansion, we are about to build another factory, and so require men with keen brains and the qualities of adaptability and leadership to fill various management posts either at our existing factory in Stoke or at the projected one in Burnley.
- This is an opportunity to join a live, progressive Company in which promotion depends strictly on merit alone.

Please write to (Mr.) A. C. McCombie,

MICHELIN TYRE CO. LTD., STOKE-ON-TRENT, *quoting reference TS4/E.*

B6895 A

THE WORLD'S LARGEST ATOMIC POWER STATION

The English Electric Company, Limited, at Whetstone, near Leicester, have several interesting vacancies for Graduate

DESIGN ENGINEERS

having at least three years' industrial experience, to tackle a wide variety of problems associated with various aspects of nuclear power. Previous atomic power experience is not essential, and men who have worked on complicated machinery, plant and conventional power station equipment, may well be suitable.

If you wish to become conversant with this rapidly expanding field of engineering, please write, giving full details of qualifications, experience and present salary, to Dept. C.P.S., Marconi House, 336/7, Strand, London, W.C.2, quoting reference E1896D.

ENGLISH ELECTRIC

E6978 A

SITUATIONS VACANT

BROWN AND POLSON LTD

Manufacturers of Starch and its derivatives

require a

DEPUTY

CHIEF ENGINEER

for their Manchester Plant

The Engineer's Department embraces Design, Development, Construction and Maintenance of equipment in Chemical, Mechanical and Electrical Engineering. The site of over 30 acres includes Wharf and Silos, Wet Milling and By-Products Division, Glucose Refinery, Dry Starch Products Division, Steam and Power (Turbo-Alternators) House.

Applications are invited from qualified engineers (degree and/or membership of professional institution) of considerable experience in this field, including preventive and/or planned maintenance schemes, age 35/45.

The Company operates an advanced policy in matters of personnel and administration. Salary and employee benefits are good.

Detailed applications to Group Personnel Manager, Brown and Polson, Ltd., 125, Strand, London, W.C.

E6982 A

STOTHERT & PITT LTD., BATH

invite applications from

DESIGNER/DRAUGHTSMEN

with experience in or akin to any of the following

VIBRATING ROLLERS, QUARRYING PLANT, TRUCK MIXERS, CONCRETE MIXERS, ASPHALT PLANTS, CONCRETE BATCHING PLANTS AND ALLIED EQUIPMENT

Local interviews can be arranged but we prefer you to visit our works for a tour of inspection, when all aspects of the work can be seen at first hand. Travelling expenses will be paid to selected applicants. GOOD SALARIES will be paid based on experience and qualifications. Assistance will be given in obtaining housing accommodation where required.

General conditions of employment are excellent. Applications, in writing or by telephone, giving details of age, experience and qualifications, which will be TREATED IN THE STRICTEST CONFIDENCE, should be made to the CHIEF ENGINEER, CONTRACTORS' PLANT DEPARTMENT, STOTHERT AND PITT, LTD., BATH (Telephone : Bath 2277).

E7041 A

LIBYAN DEVELOPMENT AGENCY

POWER STATION SUPERINTENDENT

—BENGHAZI

Engineer with considerable operational and maintenance experience of oil engines required as Superintendent of this Station, which is being extended to 6 MW. Salary £1,300 p.a. Income tax 8%. Flat and furniture available. Three-year contract offered. Please supply full details of education, training, qualifications and experience to:

Messrs. Mackness & Shipley,
Parliament Mansions,
Abbey Orchard Street,
London, S.W.1.

E7039 A

SITUATIONS VACANT

CANADA

Brown Boveri (Canada), Ltd., have ... for Engineers with experience in

TRANSFORMER DESIG...

Electrical Engineer

with at least 5 years' experience ... design and cost estimating of oil ... type transformers up to the highest ... ratings. This is a senior ... position with excellent prospects ... advancement.

Mechanical Engineer

or SENIOR DESIGNER with ... years' experience in oil and dry type ... former design to act as assistant to ... ment Head.

Both positions carry excellent sala... over £200 per month substantial ... benefits, paid passage, &c. Applicants ... be interviewed in U.K. and are ... send full particulars to A. Webb, ... Stafford Terrace, London, W.8. All ... will be treated in strictest confidence.

E...

SITUATIONS WANTED

ESTIMATING, PROJECT PLANNING, TRACTING.—Two experienced Engine... to working as a team in complete control ... for offers to undertake above work, sho... salaries would be paid, preferably Londo... BOX No. E1843, "The Engineer."

MECHANICAL ENGINEER, A.M.I... with car and office, requires Part or ... Representation, Lancs., Cheshire, Potter... No. E1842, "The Engineer."

TECHNICAL DIRECTOR (39), chief ma... engineer for 11 years, wishes to consider ... Chief Engineer, Engineer Manager, or sim... process concern or consultant. A.M.I... A.M.B.I.M., G.I.Struct.E., M.I.Plant.E... Building, &c. Sound knowledge of plan... tenance of steam raising plant, A.C. and D.C. ... generation and distribution, refrigeration, ... hydraulic machines, overhead cranes, dra... maintenance and installation of chemi... extensive experience in building construct... ing general plant layout. Capable of worki... initiative and directing all trades in m... electrical and civil engineering. Pres... £2600, but scope for future advancement ... of energy and ability more important th... salary.—BOX No. E1816, "The Engineer."

MISCELLANEOUS

REWARD FOR RESEARCH

Will pay $50 to the first perso... supplies the name and date of a publi... containing a description of a vibratory ... feeder. The bowl feeder must be for ... and/or aligning small articles of manufa... such as screws, switch components, ... and have a spiral track for the articles ... elevated, the misaligned articles ... dropped off the spiral track and the pro... aligned articles delivered to an ... device. The publication must ha... effective date prior to 1944. If ... information is desired, please write.

Charles L. Lovercheck,
1315 G. Daniel Baldwin ...
Erie, Pennsylvania, U.S.A.

FOR HIRE

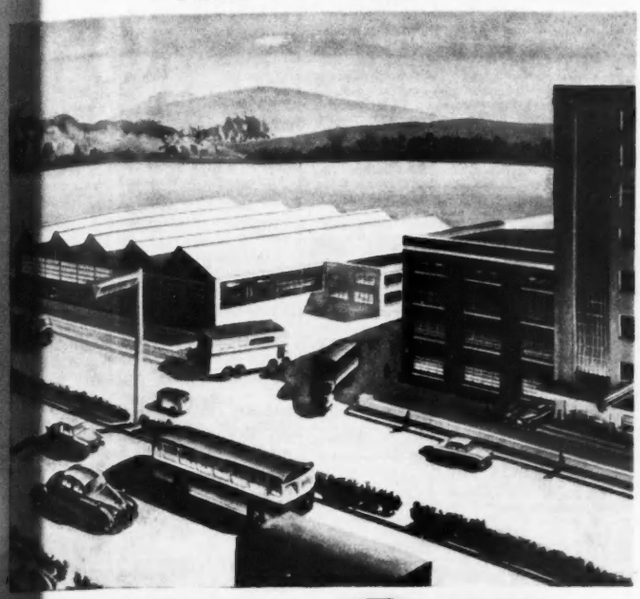
LATTICE STEEL Erection Masts ... heavy), 30ft. to 150ft. high, for immedi... Bellman's, 21, Hobart House, Grosvenor ... W.1 ('Phone, SLOane 5259).

PATENTS

THE PROPRIETOR of British Patent No. ... entitled "INDEXING MECHANISM ... MACHINE TOOLS," offers same for ... otherwise, to ensure practical working ... Britain.—Inquiries to Singer, Stern and ... 14 E., Jackson Boulevard, Chicago 4, ... U.S.A.

THE PROPRIETOR of British Patent No. ... entitled "RELEASABLE TORQUE TRANS... TING APPARATUS," offers same for ... otherwise to ensure practical working ... Britain.—Inquiries to Singer, Stern and ... 14 E., Jackson Boulevard, Chicago 4, ... U.S.A.

BUSINESSES and PREMISES



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Is your factory old, inconvenient, too small, its lease running out?

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Disposing of your existing premises? Lack of sufficient capital for new building?

PERHAPS WE CAN HELP OR ADVISE YOU!

The London County Council in co-operation with these towns has set up an Industrial Centre at the County Hall, S.E.1, to deal with London industrialists. Write (ref. VA/G, 3) or telephone for more information or an appointment—WATerloo 5000, Extension 7494 and 7595.

E6951 L

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INDUSTRIAL SITE of 1¼ acres, together with buildings containing about 10,000 sq. ft. Manager's House.

Further particulars of :

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Telephone : MONarch 3422 (8 lines).
E7011 L

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also on Models and Prototypes, &c.
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GIVE US YOUR DIFFICULT JOBS
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CANonbury 1075. E871 MW

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved. —Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E575 MW

KELLERING and Profile Milling in all metals. Send us your die blocks to copy from wood or plaster masters. Up to 5ft. by 8ft. max. size. We are die copiers to the trade.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry Knottingley, Yorkshire (Tel.: Knottingley 2743/4). E948 MW

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BLACKHEART MALLEABLE IRON CASTINGS
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Offer a Service for Detailing, Designing and Stressing in the Medium, Light, and Precision Fields of Mechanical Engineering.
All inquiries should be sent to :
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LONDON, E.1.
E1818 S

AGENCIES

COMMISSION IS OFFERED which can be quite substantial and permanent for the introduction to users of export cases, home trade cases, or any type of wood containers.—Contact BOX No. E1819, "The Engineer." D

ENGINEER EMIGRANT to Adelaide, S. Australia, interested in Representation or Agency for 1st class Machinery or Products. Experienced in light/medium production, machine tools, milling and soap machinery.—BOX No. E1836, "The Engineer." D

MACHINERY Etc. WANTED

WANTED, Machines of all Types
CASH PAID.
Norman E. Potts (B'ham), Ltd., 130, Moseley Road, Birmingham 12. VIC. 1278 1279 1270, 0856.
E123 P

WANTED, Tube Expanding Machine, Tube Cleaning Machine, 6in. to 8in. Screwing Machine, with collapsible head.—Fred Watkins (Boilers), Ltd. Coleford, Glos. E997 F

WANTED.—5000kW. Condensing Steam Turbo-Alternator Set, 400 p.s.i. steam pressure, 750 deg. F. temperature, alternator 3.3kV., 3 phase, 50 cycles. Reply.—BOX No. E7001, "The Engineer." F

600-1000kW TURBO-ALTERNATOR SET, 160 p.s.i.g., 100 deg. F. superheat, 10 lb. back pressure, preferably 400 volts, 3-phase, 50 cycles.—BOX No. E7015, "The Engineer." F

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VALES PLANT REGISTER LIMITED
OFFER FOR IMMEDIATE SALE

One Neals NM 2-ton Mobile Crane, Ruston 2VTH engine, new 1950, fitted with swan neck jib.
One Jones Super 40 3-ton Diesel Mobile Crane, 30ft. jib, Ruston engine, new 1947, on solids, recently completely reconditioned and in good condition. £1100.
One Jones Super 40 3-ton Diesel Mobile Crane, 24ft. jib, Ruston engine, on pneumatics, ex Ministry, overhauled. £1275.
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Further details : 14, Lower Grosvenor Place, London, S.W.1. Telephone : VICtoria 7531, 3501, 8080, 9886 (15 lines). E483 G

FRED WATKINS (BOILERS), LTD.

STEAM BOILERS.—Cochran Vertical (New), 8ft. 6in., 8ft., 7ft. 6in., 7ft. and 6ft. in dia., 100/150 lb w.p.; reconditioned 8ft. 6in. down to 3ft. dia.; Economic, 4ft. to 11ft. 6in. dia., including new 7ft. and 8ft. dia., 150, 180 and 200 lb. w.p.; 300 reconditioned Vertical Crosstube, all sizes.
AIR COMPRESSORS.—Broomwade 510 cu. ft.; Tilghman 365 cu. ft.; Broomwade 300, 200 and 130 cu. ft.; all motorised.
200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.
ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 100 h.p.
CRANES.—Mobile 10-ton Lorain, lorry mounted, 30ft.–70ft. extendable jib ; 4-ton Coles Diesel-Electric ; 3-ton Jones Super 40 (3) ; Neals 2-ton Diesel, 20ft. jibs (2) ; Derrick, 5-ton Butters Electric travelling type, 90ft. jib ; 5-ton Wilson Electric, 70ft. jib ; 3-ton Rushworth Electric, 65ft. jib ; Steam Loco, 18-ton Brownhoist, 50ft. jib ; 10-ton Coles, 40ft. jib ; 8-ton Wilson, 35ft. jib ; 5-ton Smith, 50ft. jib ; 5-ton Cowans Sheldon, 50ft. jib ; 5-ton Grafton, 38ft. jib ; E.O.T. Coliath, 40ft. span, 60-ton Clyde, 40-ton Babcock, 10-ton Morris ; 5-ton Henderson, 24ft. 7¼in. span, 1946 ; 5-ton King 29ft. 3in. span ; 2-ton Morris, 18ft. span, 2-ton Smith, 34ft. span.
RAILWAY MATERIAL.—150 h.p. Stephenson Diesel Loco., fluid flywheel drive ; Ruston 80/88 h.p. Diesel Loco., electric start, flameproof ; Peckett 14in. by 22in. and 7in. by 12in. Steam Locos. ; 3 miles 20 lb. Track, 24in. gauge bogies, turnouts, locos., &c.
STEEL PIPING.—50,000ft., 2in. Galvanised, new ; 60,000ft., black new ; 5000ft., 8in. seamless ; 1000ft., 12in. seamless ; 500ft., 14in. seamless ; 400ft., 18in. riveted ; 280ft., 21in. o.d. welded flanged ; 3800ft., 21in. seamless flanged ; 500ft., 24in. riveted ; 1450ft., 27in. o.d. welded flanged ; 216ft., 48in. riveted ; 216ft., 60in. riveted.
CAST IRON PIPES.—Large stocks all sizes up to 24in. flanged and s.s. Immediate delivery.
VALVES.—Exceptional Surplus Ministry Lot New Stainless Acid Cocks and Valves, over 5000, immediate delivery, below makers' prices. Large stock, all sizes, Parallel Slide Sluice, Gunmetal, Reducing and Check Valves. List on request.
STORAGE TANKS.—300 cylindrical and rectangular up to 12,000 gallons, for oil and petrol, also sectional steel and cast iron up to 50,000 gallons.
MACHINE TOOLS.—Scriven Plate Bending Rolls, 14ft. by ¾in.; Robertson Straightening Rolls, 8ft. 6in. by ¾in.; Berry Bending Rolls, 7ft. by ½in.; Tangye 300-ton Hydraulic Horizontal Straightening Press, 15ft. by 3ft. table ; Herbert 3ND Miller, 61in. by 15in. table ; Pels Punch and Shears, ¾in. capacity ; nine new 2 cwt. and 1 cwt. Pneumatic Hammers.

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EUSton 4681 and 3771.
E6924 G

Classified Advts. continued on page 132

THE HARLAND ENGINEERING COMPANY LIMITED
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An experienced man is required, with thorough knowledge of modern heavy/medium machine shop practice. Experience in fabrication assembly and jig/Tool design advantageous. Salary range £950–£1100 p.a., according to age and qualifications. Post is permanent and pensionable, and house can be offered if required. Applicants, who should preferably be qualified to H.N.C. Standard, are asked to write in confidence, stating full personal details, to the Works Manager, B.E.P. Works. E7027 A

ENGINEERS FOR MANAGEMENT

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- Owing to continued expansion, we are about to build another factory, and so require men with keen brains and the qualities of adaptability and leadership to fill various management posts either at our existing factory in Stoke or at the projected one in Burnley.
- This is an opportunity to join a live, progressive Company in which promotion depends strictly on merit alone.

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MICHELIN TYRE CO. LTD., STOKE-ON-TRENT, *quoting reference TS4/E.*

E6895 A

THE WORLD'S LARGEST ATOMIC POWER STATION

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If you wish to become conversant with this rapidly expanding field of engineering, please write, giving full details of qualifications, experience and present salary, to Dept. C.P.S., Marconi House, 336/7, Strand, London, W.C.2, quoting reference E1896D.

ENGLISH ELECTRIC

E6978 A

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The Company operates an advanced policy in matters of personnel and administration. Salary and employee benefits are good.

Detailed applications to Group Personnel Manager, Brown and Polson, Ltd., 125, Strand, London, W.C.

E6982 A

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DESIGNER/DRAUGHTSMEN

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E7041 A

LIBYAN DEVELOPMENT AGENCY

POWER STATION SUPERINTENDENT

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Engineer with considerable operational and maintenance experience of oil engines required as Superintendent of this Station, which is being extended to 6 MW. Salary £1,300 p.a. Income tax 8%. Flat and furniture available. Three-year contract offered. Please supply full details of education, training, qualifications and experience to:

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London, S.W.1.

E7039 A

CANADA

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with at least 5 years' experience ... design and cost estimating of oil ... type transformers up to the higher ... ratings. This is a senior ... position with excellent prospects ... advancement.

Mechanical Engineer

or SENIOR DESIGNER with ... years' experience in oil and dry type ... former design to act as assistant to ... ment Head.

Both positions carry excellent salaries ... over £200 per month substantial ... benefits, paid passage, &c. Applicants ... be interviewed in U.K. and are ... send full particulars to A. Wolfe, ... Stafford Terrace, London, W.8. All ... will be treated in strictest confidence.

E...

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ESTIMATING, PROJECT PLANNING, TRACTING.—Two experienced Engineers ... to working as a team in complete control, ... for offers to undertake above work, ... salaries would be paid, preferably London ... BOX No. E1843, "The Engineer."

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TECHNICAL DIRECTOR (39), chief ... engineer for 11 years, wishes to consider ... Chief Engineer, Engineer Manager, or ... process concern or consultant. A.M.I.... A.M.B.I.M., G.I.Struct.E., M.I.Prod.E. ... Building, &c. Sound knowledge of ... tenance of steam raising plant, A.C. and D.C. ... generation and distribution, refrigeration, ... hydraulic machines, overhead cranes, ... maintenance and installation of ... extensive experience in building construction ... ing general plant layout. Capable of ... initiative and directing all trades in ... electrical and civil engineering. Present ... £2600, but scope for future advancement ... of energy and ability more important ... salary.—BOX No. E1816, "The Engineer"

MISCELLANEOUS

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Will pay $50 to the first person ... supplies the name and date of a publication ... containing a description of a vibratory ... feeder. The bowl feeder must be for ... and/or aligning small articles of manufac... such as screws, switch components, ... and have a spiral track for the articles ... elevated, the misaligned articles ... dropped off the spiral track and the ... aligned articles delivered to an ... device. The publication must have ... effective date prior to 1944. If ... information is desired, please write.

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E...

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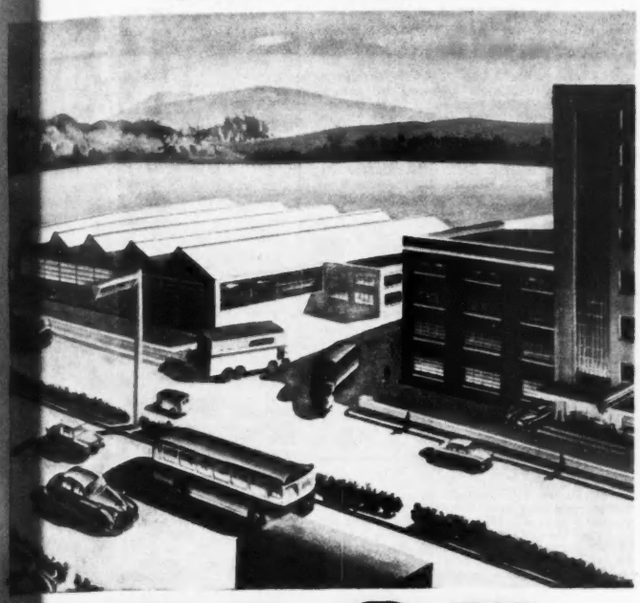

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E6951 L

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E7011 L

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E1818 S

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COMMISSION IS OFFERED which can be quite substantial and permanent for the introduction to users of export cases, home trade cases, or any type of wood containers.—Contact BOX No. E1819, "The Engineer." D

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WANTED, Machines of all Types
CASH PAID.
Norman E. Potts (B'ham), Ltd., 130, Moseley Road, Birmingham 12. VIC. 1278 1279 1270, 0856.
E123 P

WANTED, Tube Expanding Machine, Tube Cleaning Machine, 6in. to 8in. Screwing Machine, with collapsible head.—Fred Watkins (Boilers), Ltd. Coleford, Glos. E997 F

WANTED.—5000kW. Condensing Steam Turbo-Alternator Set, 400 p.s.i. steam pressure, 750 deg. F. temperature, alternator 3¢3kV., 3 phase, 50 cycles. Reply.—BOX No. E7001, "The Engineer." F

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OFFER FOR IMMEDIATE SALE
One Neals NM 2-ton Mobile Crane, Ruston 2VTH engine, new 1950, fitted with swan neck jib.
One Jones Super 40 3-ton Diesel Mobile Crane, 30ft. jib, Ruston engine, new 1947, on solids, recently completely reconditioned and in good condition. £1100.
One Jones Super 40 3-ton Diesel Mobile Crane, 24ft. jib, Ruston engine, on pneumatics, ex Ministry, overhauled. £1275.
One Jones KL44 4-ton Mobile Crane, with 24ft. jib, Ruston diesel engine, on pneumatics, new 1953, completely reconditioned and guaranteed.
One Coles 6-ton Diesel/Electric Mobile Crane, 17ft. or 35ft. jib, new 1952, on pneumatics, recent major overhaul.
One Coles 6-ton Diesel/Electric Rail Crane, 40ft. jib, standard gauge, fully slewing, magnet control gear, new 1952, in good condition.
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STEAM BOILERS.—Cochran Vertical (New), 8ft. 6in., 8ft., 7ft. 6in., 7ft. and 6ft. in dia., 100/150 lb w.p.; reconditioned 8ft. 6in. down to 3ft. dia.; Economic, 4ft. to 11ft. 6in. dia., including new 7ft. and 8ft. dia., 150, 180 and 200 lb. w.p.; 300 reconditioned Vertical Crosstube, all sizes.
AIR COMPRESSORS.—Broomwade 510 cu. ft.; Tilghman 365 cu. ft.; Broomwade 300, 200 and 130 cu. ft.; all motorised.
200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.
ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 100 h.p.
CRANES.—Mobile 10-ton Lorain, lorry mounted, 30ft.–70ft. extendable jib ; 4-ton Coles Diesel-Electric ; 3-ton Jones Super 40 (3) ; Neals 2-ton Diesel, 20ft. jibs (2) ; Derrick, 5-ton Butters Electric travelling type, 90ft. jib ; 5-ton Wilson Electric, 70ft. jib ; 3-ton Rushworth Electric, 65ft. jib ; Steam Loco, 18-ton Brownhoist, 50ft. jib ; 10-ton Coles, 40ft. jib ; 8-ton Wilson, 35ft. jib ; 5-ton Smith, 50ft. jib ; 5-ton Cowans Sheldon, 50ft. jib ; 3-ton Grafton, 38ft. jib ; E.O.T. Coliath, 40ft. span, 60-ton Clyde, 40-ton Babcock, 10-ton Morris ; 5-ton Henderson, 24ft. 7½in. span, 1946 ; 5-ton King 29ft. 3in. span ; 2-ton Morris, 18ft. span, 2-ton Smith, 34ft. span.
RAILWAY MATERIAL.—150 h.p. Stephenson Diesel Loco., fluid flywheel drive ; Ruston 80/88 h.p. Diesel Loco., electric start, flameproof ; Peckett 14in. by 22in. and 7in. by 12in. Steam Locos.; 3 miles 20 lb. Track, 24in. gauge bogies, turnouts, locos., &c.
STEEL PIPING.—50,000ft., 2in. Galvanised, new ; 60,000ft., black new ; 3000ft., 8in. seamless ; 1000ft., 12in. seamless ; 500ft., 14in. seamless ; 400ft., 18in. riveted ; 280ft., 21in. o.d. welded flanged ; 3800ft., 21in. seamless flanged ; 500ft., 24in. riveted ; 1450ft., 27in. o.d. welded flanged ; 216ft., 48in. riveted ; 216ft., 60in. riveted.
CAST IRON PIPES.—Large stocks all sizes up to 24in. flanged and s.s. Immediate delivery.
VALVES.—Exceptional Surplus Ministry Lot New Stainless Acid Cocks and Valves, over 5000, immediate delivery, below makers' prices. Large stock, all sizes, Parallel Slide Sluice, Gunmetal, Reducing and Check Valves. List on request.
STORAGE TANKS.—300 cylindrical and rectangular up to 12,000 gallons, for oil and petrol, also sectional steel and cast iron up to 50,000 gallons.
MACHINE TOOLS.—Scriven Plate Bending Rolls, 14ft. by ¼in.; Robertson Straightening Rolls, 8ft. 6in. by ¼in.; Berry Bending Rolls, 7ft. by ¼in.; Tangye 300-ton Hydraulic Horizontal Straightening Press, 15ft. by 3ft. table ; Herbert 3ND Miller, 61in. by 15in. table ; Pels Punch and Shears, ¼in. capacity ; nine new 2 cwt. and 1 cwt. Pneumatic Hammers.
SLING ENGINEERING WORKS,
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'Phone : Coleford 2271/2. E366 G

HOBBING MACHINES
SYKES VH.14 UNIVERSAL HOBBING MACHINES. For spur and worm wheels 14in. diameter. Spiral gears 14in. diameter. Max. D.P.6
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E6924 G

Classified Advts. continued on page 132

FOR SALE

SOAG

HIGH CLASS LATHES IN STOCK

No. 0 DRUMMOND ASQUITH Multi-Tool Production Lathe, motor drive, with hydraulically operated feeds to both tool slides and tailstock ; max. dia. of work 6in., max. length between centres 12in., h.p. motor 7½, 5 spindle speeds 40–135 r.p.m.

10in. REED PRENTICE 20in. Model A, motor drive, straight Vee bed, leadscrew, feed and clutch shaft, Norton type gearbox, Timken roller bearings, metric leadscrew, height of centres 10in., distance between centres 80in., swing over bedways 21½in., swing over carriage 15½in.; 16 spindle speeds from 12–530 r.p.m., spindle bore 1½in.

12½in. BROADBENT S.S. and S.C. Lathe, Model 12½. Vee belt motor drive, gap bed, Norton type gearbox, dial indicator, height of centres 12½in., swing over saddle 19in., swing in gap 47in. by 15in., admits between centres 3ft. 6in., spindle bore 3¼in., 12 spindle speeds from 6·7–230 r.p.m.; h.p. motor 12½.

14½in. BROADBENT (as above), height of centres 14½in., swing over saddle 21in., swing in gap 50in. by 15in., admits between centres 7ft. 6in., spindle bore 3¼in., 12 spindle speeds from 5·5–204 r.p.m., h.p. motor 15.

24in. MONARCH Geared Head S.S. and S.C. Lathe, type CM, with roller bearing headstock, Vee belt motor drive, flame hardened bedways, two carriages with compound slide rests with quick power traverse, taper turning attachments, swing over bed 27½in., swing over carriage 14in., between centres 24ft., 16 spindle speeds from 1·5–68 r.p.m. (can be increased), spindle bore 2⅝in., h.p. motor 15.

14in. SWIFT 12SV5 Surfacing and Boring Lathe, with Vee belt motor drive, gap bed, Norton type gearbox, four-way tool-holder, height of centres 12in., swing over bed 28in., swing over saddle 17½in., swing in gap 48in. by 18in., distance spindle to face of tool-holder 48in., 18 spindle speeds from 4–230 r.p.m., h.p. motor 15.

15in. SCHIESS DEFRIES Super-Express Lathe, Type YDE, 15½in. height of centres, between centres 10ft., with automatic controller, speed range from 20–600 r.p.m., swing over bed 34½in., swing over saddle 22in.

30½in. HARVEY Long Bed S.S. and S.C. Lathe, D.C. motor, drive through variable-speed headstock, 2 saddles with rapid power traverse by separate motors, swing over bed 61in., swing over saddles 45in., spindle speeds from 1·2–30·5 r.p.m., 3-shear bed, 54in. wide, diameter faceplate 74in.

32in. HARVEY Break Drum Lathe, with sliding bed, D.C. motor drive and variable speed headstock, Swing in gap 9ft., swing over bed 65in., swing over saddle 51in., admits between centres (gap fully opened) 25ft., speed range 0·75–38·5 r.p.m.

NEW LATHES

8¼in. MONDIALE Type Celtic Model 17 High Speed Lathe, Vee type gap bed, Norton type gearbox, swing over bed 17in., swing over cross slide 10¼in., swing in gap 25in., distance between centres 40in., speed range from 22–1000 r.p.m., 2-speed motor 5/3 h.p.

10in. MONDIALE Type Celtic Model 20 High Speed Lathe, Vee type gap bed, all-enclosed gearbox, swing over bed 20in., swing over cross slide 12in., swing in gap 30in., distance between centres 60in., number of spindle speeds 18, range of spindle speeds from 12–1000 r.p.m., 2-speed motor 6¾/4 h.p.

8¼in. PROGRES Model L440 Roller Bearing Spindle High Speed Lathe, covered Vee type gap bed, dial type gearbox, swing over bed 17¼in., swing in gap 27¼in., admits between centres 60in., speed range 11·2–1000 r.p.m., h.p. motor 7.

10¼in. PROGRES Model L550 as above, swing-over bed 22in., swing in gap 35¼in., admits between centres 60in., speed range from 11·2–1200 r.p.m., h.p. motor 9.

INSPECTION INVITED.
IT'S CHEAPER TO BUY NOW.

Full details from :—

SOAG MACHINE TOOLS, LTD.,
JUXON STREET, LAMBETH, LONDON, S.E.11.
'Phone : RELiance 7201.
E210 G

600

STEAM TURBO-ALTERNATOR SETS

3000kW., 6600/3/50, MET.-VICK., Pass-out/Condensing Steam Turbo-Alternator Set, date 1948, designed for 340 p.s.i.g. initially, 600 deg. Fah. temperature; also suitable for the following duties :

Output/kW.	Pass-out/lb./hour	Lb Pressure
3000	60,000	40
1800	40,000	110
1800	40,000	

double Pass/out at 1000kW., fully condensing.

2500kW., 440/3/50, B.T.H., speed 3000 r.p.m., 250 p.s.i.g., 630 deg. F., steam consumption approx. 12·8 lb./kW./hr., with surface condenser, circulating pumps, &c. Also suitable for pass-out pressures varying between 18/35 p.s.i.

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SONS AND CO. LTD.
WOOD LANE, LONDON, W.12.
Tel.: Shepherds Bush 2070 ; and
STANNINGLEY, NR. LEEDS.
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18-TON CAPACITY, 3 motor, cab controlled, Overhead Electric Travelling Crane by Herbert Morris, 45ft. 6in. span ; 500V. D.C., complete with Brand New Crab.

F. BURRILL & CO.,
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CARDIFF.
Tel.: 26100 E6925 G

FOR SALE

Edwards

NEW BESCO Demonstration Model High-Duty, Double-Geared Guillotine Shearing Machine, overcrank type, Model "R," capacity 72in. by ¼in., mild steel, arranged motor drive 400/440/3/50, length of blade 72in.

ROBERTSON Power-Operated, Double-Geared Gang Slitting Machine, capacity ¼in. thickness, diameter of shaft 4½in., between housings 24in.

BESCO Type CGF, size 97in. by 4in., Hand-Operated Geared Slip Bending Roller, for floor mounting, with cast iron side frames and three steel rollers ; the front bottom roller is arranged to swing outwards for removing complete cylinders. Weight approximately 1380 lb.

BESCO Open-End Angle Iron Bending Machines Type M14A, arranged motor drive for 380/420/3/50, mounted on baseplate and cast iron floor stand, capacity up to 1¼in. by 1¼in. by ¼in.; the upper roll is made to rise so that complete circles may be withdrawn. Weight approximately 10 cwt.

SUPER SPEED Press, arranged for motor drive 400/440/3/50, with Reeves variable-speed drive unit, rated capacity 10 tons, maximum width stock cut-off 9in., maximum length of blank 3in., size of die bed 9½in. by 11in.

NEW BROOM and WADE Motor-Driven Air Compressor Unit, comprising type NX vertical, single-cylinder, air-cooled air compressor, fitted with inlet air filter and air governor, capacity 3 cu. feet per minute, delivered at 100 lb. per square inch pressure, arranged motor drive for 380/420/3/50.

Photographs of the above are available.

MACHINE TOOLS, NEW AND USED,
Of Every Description. Attractive Prices.

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E207 G

ABELSON offer the following equipment for immediate delivery :—

Smith 5-ton capacity Rail-mounted Steam Loco. Crane. New 1951.

Fully reconditioned Fowler 150 H.P. 0-4-0 Diesel Locomotive.

First-class Barclay 0-4-0 84 H.P. Diesel Locomotive.

First-class Ruston 0-4-0, 48 H.P., Diesel Shunting Loco.

All the above machines suitable for 4ft. 8½in. gauge.

For further details contact :

ABELSON AND CO. (ENGINEERS), LTD.,
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E7005 G

TRACTORS.—Three Tractors for sale, one Fordson, year 1942 ; two D2 Caterpillar Tractors, year 1953.—Can be seen week commencing Monday, 28th April, at James Kilpatrick and Son, Ltd., Lounsdale Works, Meiklerigg, Paisley. Telephone : PAI 4264. OFFERS. E1840 G

FOR SALE

TWW

USED "OMA" SL.800 GEAR SHAPING MACHINES, maximum diameter of external gears with 4in. cutter—8in., with 1⅛in. cutter—10½in., maximum height external and internal gears 2in., self-contained motor drive for 340/3/50 cycles, with guides for helical and straight gears.

UNUSED "ORMEROD" 12in. stroke SLOTTING MACHINES, maximum diameter admitted 4ft., maximum height 1ft. 6in., 2ft. 3in. diameter table, with new 10 h.p. motor and starter for 400/440/3/50 cycles supply.

USED "DARLING & SELLERS" 10½in. GAP BED S.S. and S.C. LATHE, to admit 6ft. 2in. between centres, spindle speeds 10–226 r.p.m., arranged for self-contained motor drive for 400/440/3/50 cycles supply.

REBUILT "WARD, HAGGAS & SMITH" RACK-DRIVEN PLANING MACHINE, table surface 8ft. by 2ft. 4in., distance between uprights 2ft. 7in., distance under cross rail 2ft. 6in., one toolbox on cross rail and one side box, self-contained motor drive, 20 h.p. motor for 400/440/3/50 cycles supply.

THOS. W. WARD LTD.
ALBION WORKS - - - SHEFFIELD
'Phone : 26311. 'Grams : "Forward."
E214 G

FOR SALE

¾ cu. yd. Rapier 410 Diesel-driven Excavator with 4-purpose or dragline equipment.

¾ cu. yd. Rapier 423 Diesel-driven Excavator with Shovel or Dragline equipment.

1 cu. yd. Rapier 440 Diesel-driven Excavator with Shovel or Dragline equipment.

5-ton Morris Versatile Diesel/Elec. Mobile Crane on solid rubber tyres.

5-ton Smith Steam Loco., 4ft. 8½in. gauge, 35ft. jib.

6-ton Standard Rapier Pet./Elec. Mobile Crane on solid rubber tyres.

6-ton Super Rapier Pet./Elec. Mobile Crane on solid rubber tyres.

Chaseside Loadmaster "500" 1 cu. yd. Diesel-driven Loading Shovel. New 1957.

WILLIAM G. SEARCH LIMITED.
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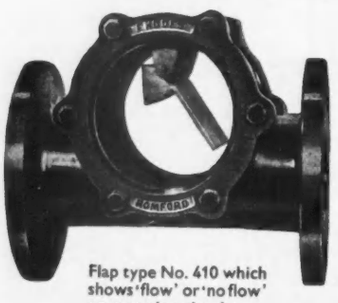

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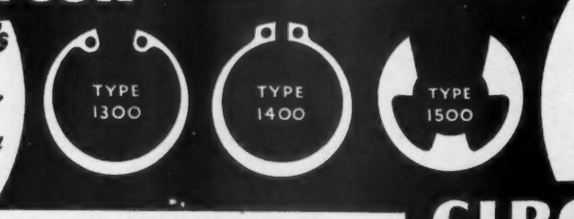

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AUCTION PROGRAMME

		Main Location	*Auctioneers*
May 7–8	**Machine tools and miscellaneous stores,** including sewing machines, paint, etc.	Technical Stores Sub-Depot, Old Dalby, Melton Mowbray, Leics. (Sale at Melton Mowbray.)	SHOULER & SON (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 81.)
May 12–16	**Vehicles, lifting equipment, trailers, motor cycles, etc.**	M.O.S. Storage Depot, Ruddington, Notts.	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.)
May 15	**Miscellaneous stores,** including furniture, hand tools, etc.	General Stores Sub-Depot, Longtown, Nr. Carlisle. (Sale at County Hall, Carlisle.)	HARRISON & HETHERINGTON, LTD. (Dept. L), Botchergate, Carlisle. (Tel.: 26292/3.)
May 22	**Miscellaneous stores,** including :—	M.O.S. Storage Depot, Rotherwas, Hereford.	RUSSELL, BALDWIN & BRIGHT, LTD. (Dept. L), 20 King Street, Hereford. (Tel.: 4366.)
	Large quantity of tyres and inner tubes, A.E.C., Standard, Gardner, Humber, Commer, Hillman, Karrier and other petrol and diesel engines, large quantity of ball and roller bearings, M/T spares and equipment, marine engines and boat spares, diesel engined road roller, concrete mixers, petrol-driven mobile conveyor, water pump, electric cable, electrical and wireless equipment, household furniture and bedding, armoured hose, Adcock & Shipley 21in. drilling machine, etc.		
May 29–30	**Miscellaneous stores,** including electrical fittings, etc.	No. 1 E.S.D., Long Marston, Nr. Stratford on Avon, Warwickshire.	LOCKE & ENGLAND (Dept. L), 116, Parade, Leamington Spa. (Tel.: 2833.)
June 3	**Machine tools, cranes and miscellaneous stores,** including furniture, etc.	M.O.S. Sub-Depot, Lily Lane, Byley, Middlewich, Cheshire. (Sale at New Islington Public Hall, Ancoats, Manchester.)	J. H. NORRIS & SON (Dept.L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
June 6	**Miscellaneous stores.**	Returned Stores Depot, Reed Hall, Colchester, Essex	FENN, WRIGHT & CO. (Dept. L), 146, High Street, Colchester, Essex. (Tel.: 3171.)

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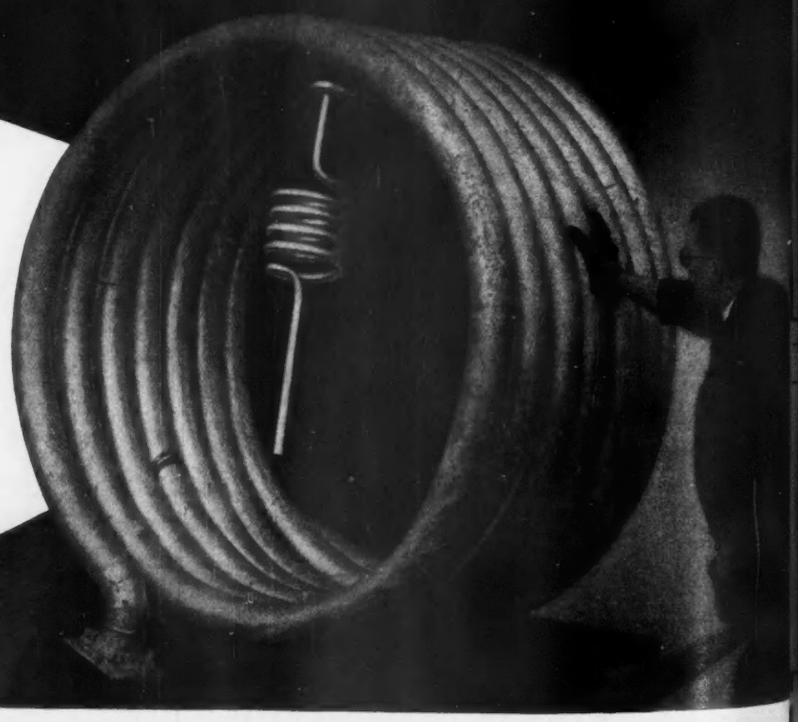

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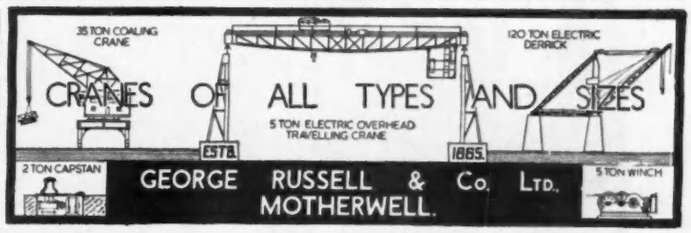

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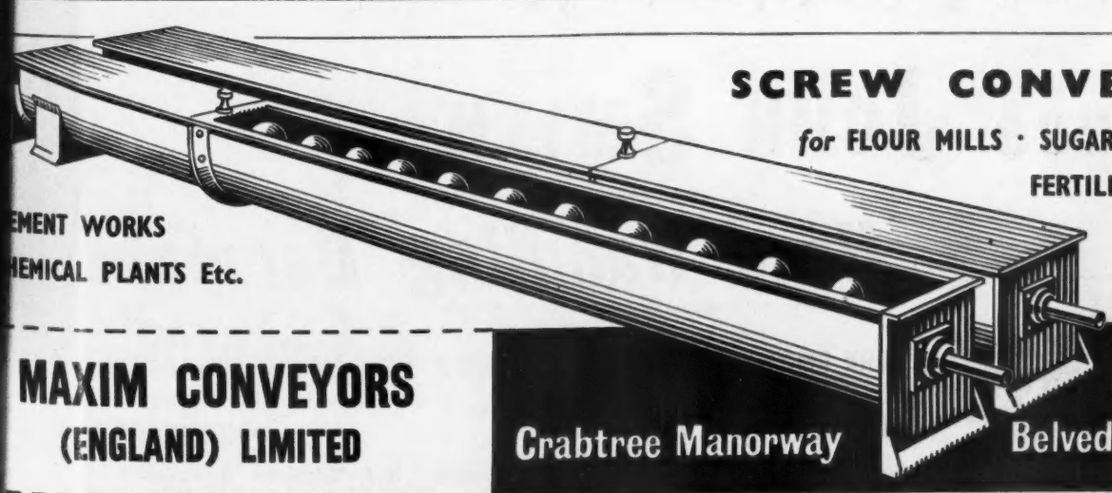

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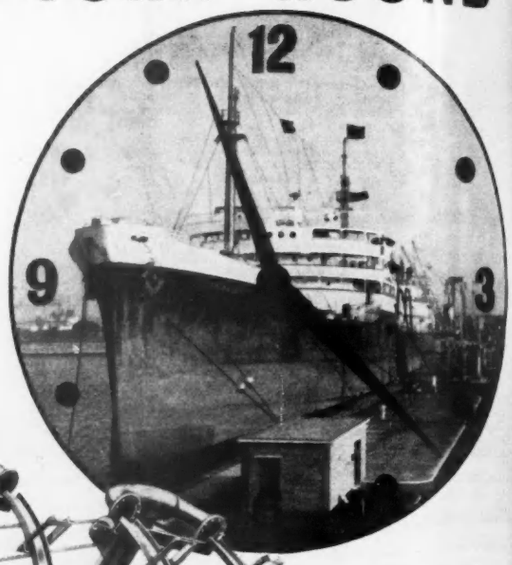

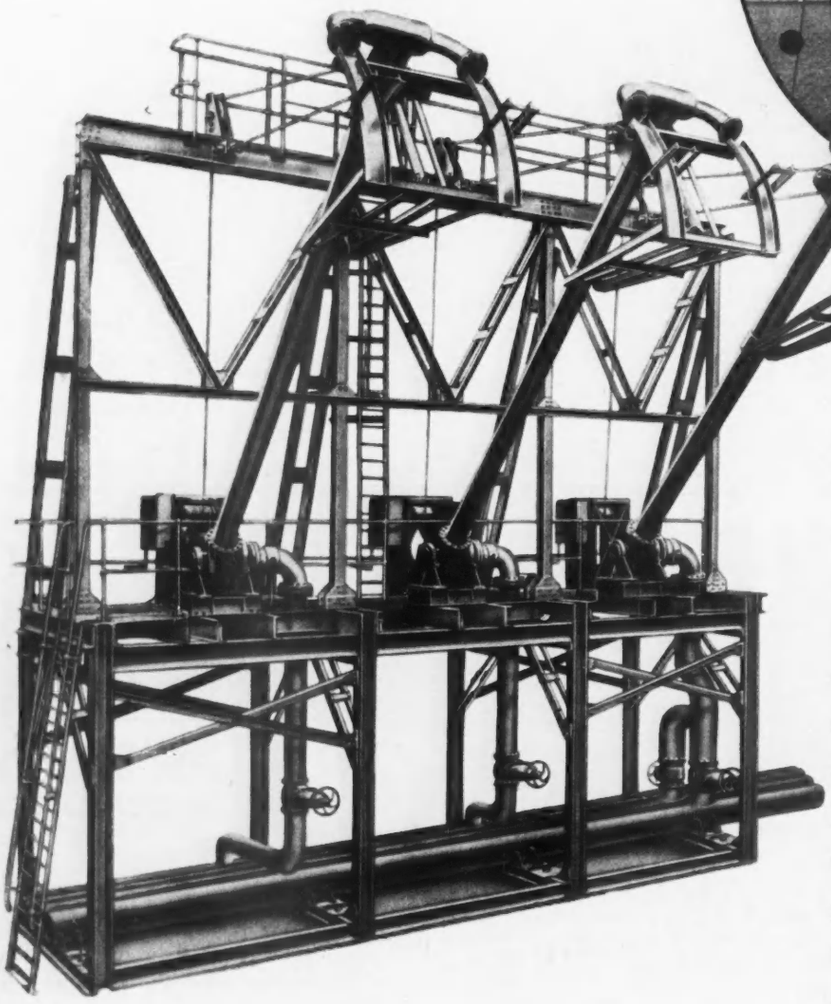

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